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Motivation and support services in citizen science insect monitoring: A cross-country study☆,☆☆

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ABSTRACT

The design and successful performance of citizen science-based monitoring require an understanding of the motivation and the needs of participants. Herem we use a questionnaire to assess intrinsic and extrinsic motivations and investigate in links between project support service and motivations in 181 participants taking part in three insect-focused citizen science projects in Denmark, Germany and Israel. Across all three countries, main intrinsic motivation for participating in the projects were "to have fun" and to "do something (good) for nature". Equally important across all countries were extrinsic motivations such as "contribute to science" and "contribute to nature conservation". Interestingly, differences in the projects (country or program-type) were more strongly related to respondent's motivation than demographic variables such as age and gender. Linking project support services to participants' intrinsic and extrinsic motivations revealed that the intrinsic motivation of "feeling a part of the community" as well as the extrinsic motivation "learning" and the service to provide "training on insect identification" were positively related. Interestingly, the support service of "monetary incentives" was negatively related with the motivation to "conserve species generally" and "conserve insects specifically". We conclude, that early identification of the citizen scientists' motivation and the assessment of how motivations may change over time are important to foster successful and sustainable citizen science monitoring programs. International networks of (potentially similar) biodiversity monitoring schemes should consider differences in cultural background and citizen scientist's requirements, and accordingly tailor the projects designs to activate, train, and support participants according to their needs.

☆ **Data accessibility**: We provide most of the data of this study within the paper and as supplementary material. Extended data are available on request from the authors.☆☆ **Ethics review process**: The findings of this study derived from an anonymous questionnaire answered by participants of the monitoring programs under study. The questionnaire was subject to the most recent data protection guidelines in all three countries (Denmark, Israel and Germany) and approved and authorized by UFZ Datenschutz (Data Protection Committee), Leipzig, Germany (23/06/2017) and by the Natural History Museum of Denmark in Copenhagen. For all the German routes and drivers, individual permits to collect insects, as regulated by the German national law, were provided by state and regional conservation authorities. Human ethics approval for this research was provided for the BMS-IL through Tel Aviv University's Research Authority. All respondents gave informed consent to participate in the study before completing the questionnaire. The participation of the survey was voluntary and no compensation was provided.

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1. Introduction

Insect conservation has been recently moved into mass media and the policy spheres with the notion of dramatic declines of insects (Hallmann et al., 2017; Sánchez-Bayo and Wyckhuys, 2019) and the promotion of associated narratives such as the windshield phenomenon (Vogel, 2017) and the "Insectageddon" (Monbiot, 2017). While it is clear, that trends in insect populations and biomass vary across spatio-temporal gradients and require differentiated assessments (see Van Klink et al., 2020, Bowler et al., 2021; Montgomery et al., 2020, Thomas et al., 2019), it is also clear that many taxa in many regions are experiencing dramatic declines. For example, rapid rates of declines have been reported for butterflies and moths in the UK and across European countries (Macgregor et al., 2019; Warren et al., 2021), and in wild bees in the US (Mathiasson and Rehan, 2019). Scientists are in consensus that anthropogenic stressors such as land use and land-use change (particularly by agriculture expansion and growing urbanization), pollution, and climate change are main drivers of biodiversity declines (IPBES, 2019). There is also an increasing recognition of long-standing data gaps for the majority of insect taxa (Eisenhauer et al., 2019; Van Klink et al., 2020, Conrad et al., 2006). Monitoring schemes are increasingly acknowledged as key to assessing the status and trend of insect distribution and abundance (Saunders et al., 2020). Biodiversity monitoring networks, such as the Group on Earth Observations Biodiversity Observation Network (GEO BON), help structure, harmonize and standardize data and information about global biodiversity that allow for meaningful assessments of the rates of biodiversity changes (Kissling et al., 2018; Navarro et al., 2017; Proença et al., 2017). By realizing the long-term engagement of many stakeholders in biodiversity recording, much emphasis is now also placed on supporting the many existing initiatives and fostering their integration (Kühl et al., 2020). In addition, new monitoring schemes are needed, at national and global scales, to overcome major information gaps about biodiversity (Proença et al., 2017). Monitoring of insects thus needs to go beyond national schemes designed to address the magnitudes of insect declines (Wagner, 2020). So far there are only few initiatives to achieve global monitoring of insects. These include proposals for global butterfly monitoring (Van Swaay et al., 2015), EU-wide pollinator monitoring (Potts et al., 2020), and a Global Mosquito Alert (Tyson et al., 2018a, 2018b, 2018c). Such efforts, which may help address the immense knowledge gaps regarding insect declines and their impacts, primarily rely on volunteers to participate in citizen science-based, standardized monitoring schemes.

People voluntarily taking part in citizen science initiatives and contributing to research activities (Bonney et al., 2009), are making significant contributions to many national biodiversity monitoring schemes (Chandler et al., 2017; Pocock et al., 2015). In fact, in some regions, the majority of biodiversity records are provided by citizen scientists (Schmeller et al., 2015), and would not exist without the contributions of the thousands of volunteers (Cooper et al., 2014; Sullivan et al., 2009; Van Swaay et al., 2015). For butterflies, a long history of citizen science involvement exists, particularly for many European and North American countries. For example, the UK Butterfly Monitoring Scheme (https://ukbms.org/) is one of the oldest-known long-term citizen science monitoring project for butterflies, running since 1976 (Thomas et al., 2019). Newly established infrastructure, such as international citizen science platforms like eButterfly (https://www.e-butterfly.org/), and initiatives to establish new schemes, such as through the ABLE project in Europe (https://butterfly-monitoring.net/able), allow citizen scientists to easily report butterfly occurrence and abundance using their mobile phones. Understanding the motivations of volunteer citizen scientists, and how monitoring schemes can best support participants to fulfil those motivations, is essential for the success of all citizen science schemes - regardless of scale - and the effectiveness of the associated research (Pocock et al., 2018; Rotman et al., 2012; Roy et al., 2012a, 2012b).

1.1. Motivation

To be motivated means to be moved to do something (Ryan and Deci, 2000a). Motivations for volunteering differ depending on individual factors (e.g. gender, age, and cultural background) or one's attitudes, social norms and experience (Beza et al., 2017; Clary et al., 1998; Randle and Dolnicar, 2009). Research on the factors determining participant's motivation to contribute to citizen science projects are evolving with the rise of citizen science (Follett and Strezov, 2015; Jordan et al., 2011). Studies have assessed the motivations of participants in citizen science in general (Ganzevoort et al., 2017; Geoghegan et al., 2016; Kragh, 2016; Land-Zandstra et al., 2016), revealing a range of motivations, from social and physical enjoyment (Van Den Berg et al., 2009), to increasing skills in scientific literacy (Bonney et al., 2009), and contributing to scientific knowledge (Geoghegan et al., 2016). In crowdsourced- citizen science projects, such as *Eyewire* (https://eyewire.org) or *Foldit* (https://fold.it/), which include inherent components of gamification, the spectrum of motivation ranges from external-rewards to intrinsically-driven motives. This indicates that extrinsic motivations - such as competition, a system of rewards, or feeling part of a larger social community - are important motives for the players taking part in these games attributing scientific questions (Tinati et al., 2017; Curtis, 2015). Moreover, an individual's contributions to digital and virtual citizen science projects was found to be linked with their motives; higher contributions were driven by societal or competitive features (Eveleigh et al., 2014).

Despite the variety and diversity of conservation-based citizen science, limited knowledge exists why individuals choose to engage in such monitoring schemes (Maund et al., 2020), and how these motivations differ in different contexts. Current understanding about motivation in conservation-based citizen science highlights the desire of participants to contribute to science (Larson et al., 2020), to help with wildlife conservation (Geoghegan et al., 2016; Larson et al., 2020) and to contribute to conservation decisions at the local level (Tulloch et al., 2013). Further, it is known that motivations to participate include a desire to gain scientific understanding (Geoghegan et al., 2016; Tulloch et al., 2013) and to experience and value outdoor recreation wherein one can enjoy learning about and from nature (Larson et al., 2020; Ng et al., 2018; Domroese and Johnson, 2017).

1.2. Knowing how best to support participants' needs

Organizational features of a volunteer scheme can support volunteers' motivational goals (Heckhausen and Heckhausen, 2008). Success in citizen science is expected to be linked with the provision of support services provided by the project, to facilitate the entry and involvement of the people taking part (Machin and Paine, 2008; West and Pateman, 2016). For example, training, autonomy, providing feedback, and a choice of volunteer activities at different skill levels, can positively impact on volunteers' motivation to join, and to stay involved (Studer and Von Schnurbein, 2013). It is poorly studied, however, which support services volunteer schemes need to provide to address volunteers' motivation – yet such knowledge has implications for the design and effective implementation of citizen science schemes. Specifically, citizen science managers and coordinators should tailor recruitment, communication, engagement strategies, participant involvement and feedback, to ensure motivational expectations are met (Clary et al., 1998; Ng et al., 2018). This becomes particularly important when international schemes are desired for long-term monitoring to assess global biodiversity.

1.3. The self-determination theory

Citizen science as a research field has slowly advanced from the main focus of approaches in nature conservation to developing interdisciplinary citizen social science approaches (Pykett et al., 2020). Yet, largely underutilized in most citizen science, some sub-fields of social science, such as psychology, are more often used (Tauginienė et al., 2020).

Despite citizen science relying on people, there are few applications of psychology in the field. There is thus large potential, and a need, for psychological theory to better understand peoples' behaviors and the motivations for participation in citizen science projects (Funke, 2017). Specifically, the application of psychological theories of motivation can help identify the personal and situational factors that are required to elicit, sustain or enhance motivations for becoming involved (Wu et al., 2016). Here, we apply the Self-Determination Theory (Ryan and Deci, 2000b) to understand citizen scientists' motivation for participating in insect monitoring schemes. The Self-Determination Theory proposes two different types of motivation (Ryan and Deci, 2000a): intrinsic and extrinsic. Intrinsic motivation is "doing an activity for the inherent satisfaction of the activity itself" (Ryan and Deci, 2000b). Intrinsically motivated people choose to act for the enjoyment or challenge of the activity rather than for external rewards or pressure (Ryan and Deci, 2000a) e.g., participants may engage in an entomology project because they enjoy watching insects in nature. Extrinsic motivation is target-oriented behaviour where people act because their behaviour may result in positive outcomes or the avoidance of negative outcomes (Ryan and Deci, 2000a). For example, participants engage in a conservation-based project to advance science or feel needed (Rutten et al., 2017). Extrinsically motivated people choose to act because of the promise of rewards (e.g. social status) or incentives (e.g., payment for participating in citizen science projects or positive self-evaluation or evaluation by others), or to avoid pressure or punishments (e.g. warnings of potential damage to nature or science if the citizen science project fails).

1.3.1. Self-determination theory in citizen science

The Self-Determination Theory has formerly been applied in a few studies aimed at understanding motivation in citizen scientists (Nakayama et al., 2019; Ng et al., 2018; Rutten et al., 2017; Zhao and Zhu, 2014). In a systematic literature review, Rutten et al. (2017) assessed motivational aspects for conservation-based citizen science projects with a focus on monitoring goals. Enjoyment was the most frequently mentioned intrinsic motivation while learning, contributing to science, social contacts and enhancing reputation or self-esteem were the most common extrinsic motivations for participating in conservation-based citizen science (Rutten et al., 2017). Nov et al. (2014) showed that enjoyment and fun (intrinsic motivation) were the second most important motives for individuals to get involved in technology-based citizen science projects, while reputation (extrinsic motivation) was of least importance to participants. The primary motivation of volunteers in a nocturnal owl survey was intrinsic (i.e. personal enjoyment of birding, being in nature and spending time with friends), rather than extrinsic (i.e. conservation, professional or educational motivations; Ng et al., 2018). Tiago et al. (2017) found the frequency of participation significantly differed based on the level of intrinsic motivation though more frequent participation was always related to an increase in variables associated with the Self-Determination Theory.

Support services provided by the citizen science scheme can help reinforce volunteer's intrinsic and extrinsic motivations. Zhao and Zhu (2014) found that providing services to support a participant's perceived motivational benefits reinforced the relationship between the individual's internal (i.e. intrinsic) motivation and their determination to participate in the crowdsourcing project. Finally, Nakayama et al. (2019) showed that a greater increase in productivity took place when assigning participants to the task based on a combination of individual attributes.

1.4. Aims of the study and research questions

In our study, we use the Self-Determination Theory to investigate participant's motivation for taking part in three insect-focused citizen science projects from Denmark, Germany and Israel. To gain insight into how volunteer schemes can best support the needs of volunteers to achieve their motivational goals, we also assessed the needs and expectations of the participants regarding support services provided by the citizen science projects. Specifically, we ask the following research questions (RQ):

- RQ1. What are the participant's motivations for engaging in insect monitoring citizen science projects?
- RQ2. How do motivations differ by age, gender, identification skills and country in citizen scientists?
- RQ3. What support services do participants want from the citizen science project?
- RQ4. How can the understanding of the association between participants' motivation and support services inform better citizen science project design and management?

2. Material and methods

2.1. Three insect-focused citizen science projects

Three insect-focused citizen science projects were assessed in this study. When referring to people taking part in these projects, we use the word "citizen science scientist(s)" or "volunteer(s)". We use the term "respondent(s)" when referring to people who participated in our study.

In Denmark and Germany, the citizen science project 'The Insectmobile'designed by the Natural History Museum of Denmark was carried out in Denmark in the summer 2018–2020 and in Germany in the summer 2018–2019. The 'Insectmobile'project examined insect biomass and diversity across a range of land-use categories and intensities (Svenningsen et al., 2021.). The project engaged citizen scientists to collect insects between June and July using their private cars by driving twice along predetermined routes with car nets on rooftops to catch insects (Fig. 1). Volunteers were asked to conserve the insect samples in ethanol before sending them back for subsequent analyses. Citizen scientists in Denmark were recruited through both local and national new media and social media during April and May 2018. In Germany, recruitment was carried out via existing networks as the number of participants was restricted due to the limited number of car nets that could be provided to the volunteers. It was required for the volunteer(s) to own a car to perform the sampling. Thus, the 'Insectmobile'project allowed all adults above the age of 18 with access to a car to volunteer for insect sampling and no insect identification skills were required. The citizen scientists were provided with a sampling protocol, a sampling kit and two individually designed 5 or 10 km routes close to their home address. Postage to return the materials and samples was prepaid. Lastly, each volunteer received species lists of the insects collected on their routes. In 2018, more than 170 volunteers in Denmark and 29 volunteers in Germany participated in 'The Insectmobile' project.

In Israel, the Butterfly Monitoring Scheme (hereafter BMS-IL; Comay et al., 2020), established in spring 2009, aims to collect information about the presence, abundance and phenology of butterflies. Volunteers follow the 'Pollard Protocol' (Pollard, 1977; Pollard and Yates, 1993; Van Swaay et al., 2015) by walking a constant transect of 300–600 m every two weeks and reporting the number of butterflies they observe in an imaginary 5 × 5 × 5 m cube. Participants were asked to perform observations twice per month over at least 9 months a year. In 2018, 80 volunteers participated in the BMS-IL. Participants were initially recruited from the members of The Israeli Lepidopterists Society (an NGO). Later on, many volunteers were organized into "communities", led by local municipalities and conservation-oriented organizations (both NGOs and GOs). Nowadays, newly recruited volunteers are trained both indoors (lectures) and outdoors; and members of local communities meet regularly to exchange knowledge, experiences and photos, and to discuss professional questions. All BMS-IL volunteers are invited to an annual conference to further facilitate exchanges and learning. The level of taxonomic expertise among participants in the

Fig. 1. An insect net installed on the roof of a car for the 'InsectMobile' project.
Photo credit: S. Hecker.

Israeli Butterfly Monitoring Scheme has changed over the years. At the start of the scheme in 2009, all of the (few) volunteers were butterfly experts recruited via The Israeli Lepidopterists Society. Following the instalment of the scheme, an increasing number of members of the general public are joining the scheme and offered a training course as a prerequisite for participation. The training course includes lectures about nature conservation in general and butterflies specifically, as well as field trips with butterfly experts to train in species detection and identification. By the end of their training, volunteers that are novices relative to professional lepidopterists still know more about butterflies than untrained lay people; and a rapid learning curve could be seen (Comay et al., 2021). All BMS-IL volunteers are supported by online tools, an identification guide, a web portal for reporting and viewing observations, and smartphone applications. There is no skill test before active participation, but volunteers are encouraged to report uncertain taxonomic identifications at the genus, family or even order level. BMS-IL has no age limit, but children are accompanied in the field by adults. Many of BMS-IL's volunteers are retired.

2.2. Similarities and differences of the three projects

All three projects focus on gaining data and information about insect biodiversity, using standardized protocols and engaging members of the public in collecting the data. Each volunteer scheme is led by a team of coordinators and researchers. The projects share common protocols with similar schemes in other countries and collaborate with associates from other research institutions and NGOs that operate the schemes and enable the analysis of the data.

The entomological background of the volunteers in the three projects, however, varies greatly. In Denmark, the majority of volunteers are the general public. In Germany, 18 out of 29 participants in 2018 were entomologists. Thus, our study design is based on generating comparability between two programs whose participants are among the community of insect-experts (Germany & Israel) compared to non-professionals (Denmark); and two programs focusing on insects in general (Denmark & Germany) compared to butterflies specifically (Israel) (Table 1).

2.3. Recruitment of survey participants

All citizen scientists in the three projects were invited to take part in our study, while the recruitment of participants to our study varied by country. In Denmark, all volunteers of'The Insectmobile' were invited to take part in an online questionnaire (SurveyXact (Ramboll)). In Germany, all volunteers of'The Insectmobile' received a paper version of the questionnaire. In Israel, all volunteers of the BMS-IL were sent an online questionnaire via the Google Forms software. All participants gave informed consent before participating in the survey. The research

Table 1
Overview of the three insect-focused citizen science projects with shared characteristics and differences.

Country	Protocol	Procedure	Target group	Survey participants (project volunteers)
Denmark Germany	InsectMobile InsectMobile	Drive a car with an insect net in a fixed route, twice in June or July.	Lay persons Volunteering entomologists	110 (172) 27 (29)
Israel	Butterfly Monitoring	Walk a fixed transect, record species and no. of individuals of all butterflies twice per month.	Amateur entomologists	44 (80)

was approved by Data Protection offices of the participating institutions.

2.4. Sections of the questionnaire

A questionnaire assessed respondents' motivations for taking part in their respective citizen science project and the importance of support services to fulfil their motivations (Panel S1). Each questionnaire was translated to the key native languages of the countries (Danish, German and Hebrew). Responses were then translated back into English for the analysis.

The first section contained nine items focused on respondents' intrinsic and extrinsic motivations, based on items and themes used in other citizen science studies (Geoghegan et al., 2016; Rutten et al., 2017; Tiago et al., 2017). Intrinsic motivations were assessed with two items: "Have a lot of fun"; "Fulfil my personal desire to do something for nature". Extrinsic motivations were assessed with seven items: "Help to conserve species generally"; "Help to conserve insects specifically"; "Contribute to science"; "Learn something new"; "Share my knowledge"; "Feel a part of the community"; "Contribute to the conservation of nature". Respondents rated how much they agreed with each item on a 5-point scale (1 = strongly agree to 5 = strongly disagree). None of these items were negatively worded, framed or reverse coded.

The second section asked about the importance of support services provided by the citizen science projects. Support services were based on the services already provided by the three insect-focused citizen science projects (e.g. mobile apps, training events) or recommended in guidelines on how to best design citizen science projects (Pocock et al., 2014; Van Swaay et al., 2015). Support services were assessed with the following 10 items: "Training courses on insect identification"; "Training courses on how to use the provided material"; "Exchange with scientists"; "Exchange with other participants of the project"; "Participation in data analysis"; "Participation in data interpretation"; "Participation in result interpretation"; "Receive findings"; "Receive monetary incentives (tax reduction on petrol, free entry at the museum, prizes)"; "Receive a certificate". Respondents rated how important each service was on a 5-point scale (1 = not important, 5 = very important).

In the final third section, the questionnaire assessed insect identification skills. In a single item, respondents were asked to rate their "general expertise and knowledge about [insects or butterflies, depending on the project]" on a 5-point scale (1 = poor to 5 = excellent). Demographic information provided by respondents included biological gender, age, country. These data were used as covariates in our analysis. Detailed information on the survey instrument is provided as supplemental material (Panel 1).

3. Statistical analyses

The analysis was conducted using RStudio (version 3.5.1; R Core Team, 2018). Observations with missing data (e.g. respondents that did not wish to indicate their gender or age) and "not applicable" (N/A) responses were omitted from the analyses. Statistically significance was set at $\alpha \leq 0.05$. Differences in respondent demographics across the three countries were analyzed using Cumulative Link Models (CLMs) with age and gender as ordinal response variables and country as predictor variable. To test for differences in identification skills across respondents in the three countries, we used CLMs with identification skills as a response variable and country, gender and age as predictors variables. Ranking motivation items for all countries as well as for each country was used to investigate the overall participant's motivations for engaging in insect monitoring citizen science projects (RQ1).

To explore the associations between motivations and demographics, identification skills and country (RQ2), we conducted CLMs using the R "ordinal" package (Christensen and Brockhoff, 2013). Agreement ranks (from "strongly disagree" to "strongly agree") of the motivation items as ordinal data. The following covariates were included in each analysis: country (categorical), gender (categorical), age group (transformed to numeric, i.e. "under 18" = 1, "18–25" = 2, etc.) and self-assessed identification skills. We used the models' coefficients and *p*-values for each covariate to assign the relative agreement (importance) to each motivation item. To understand the ranking of motivations or support services of citizen sciences within countries (RQ2 and RQ3), we conducted CLMs using the R "ordinal" package (Christensen and Brockhoff, 2013). We modelled the agreement level with the motivation item (from "strongly disagree" to "strongly agree") or the importance level of the support service (from "not important" to "very important") as the response variable. The specific motivation or support service item was a non-random covariate, and the country was a random covariate (as it was significant in almost all motivation or capacity specific models (see below). The coefficients of the motivations (or support services) indicate their relative importance (e.g. motivations with higher coefficients are more important than those with lower coefficients). After analyzing the whole survey, we repeated the process and created separate models for each country. Further, to investigate the relationships between motivations and support services (RQ4), we computed the Spearman rank correlations (Fig. 5) using the R package "psych" (Revelle, 2017). For both within and between country analyses (RQ 1 and 2), all significant *p*-values were corrected for multiple comparisons using the False Discovery Rate, with the R function "p.adjust". For the graphs, statistically significant ($\alpha \leq 0.05$) differences between countries were identified with different letters. When assessing differences in motivations within countries, all motivation items were arbitrarily compared to item "conserve species in general". Statistical analysis was conducted on the original ordinal scale. For graphically plotting, the means and standard deviations were calculated after transforming the ordinal importance and agreement levels to a numeric scale, from "not important"/"strongly disagree" (plotted as "0") to "very important"/"strongly agree" (plotted as "4").

4. Results

Out of 403 volunteers who received the survey, responses were obtained from 181 persons: 110 in Denmark (response rate 57%), 27 from Germany (90%) and 44 from Israel (55%). Slightly more than half of all respondents were male (59%) with two respondents (1%) assigned themselves as neither male nor females. All respondents were above 26 years of age, with 79% aged 46 years old or older (Table S1). There were no significant differences among the respondents of the three countries with regards to age and gender. Overall, 69% of all respondents rated their insect identification skills as either "good" or "very good" (Table S1). Testing for any difference among countries in respondents' self-reported insect identification skills revealed that respondents from Germany rated their own expertise higher than did respondents from Denmark (coefficient = 2.43; p-value <0.001) and Israel (coefficient = 2.21; p-value <0.001). Respondents from Denmark did not differ significantly in their self-assessed expertise from those from Israel. Men rated their own expertise higher than did women (coefficient = 0.66; p-value = 0.025).

4.1. Motivation of citizen scientists

Across the entire sample, both intrinsic and extrinsic motivations were important to respondents, with around half of all respondents ($\geq$54%) agreeing or strongly agreeing with all items (Fig. 2, Table S3). The most important motivation items for participating in the citizen science projects were the extrinsic motivations "contribute to science", "contribute to the conservation of nature" and "conserve insects specifically", as well as the intrinsic motivations "fulfil my personal desire to do something for nature" and "have a lot of fun" (Fig. 2). The extrinsic motivations "learn something new", "share my knowledge" and "feel a part of the community" were least important. In short, individuals were nearly always motivated by a mix of intrinsic and extrinsic motivations.

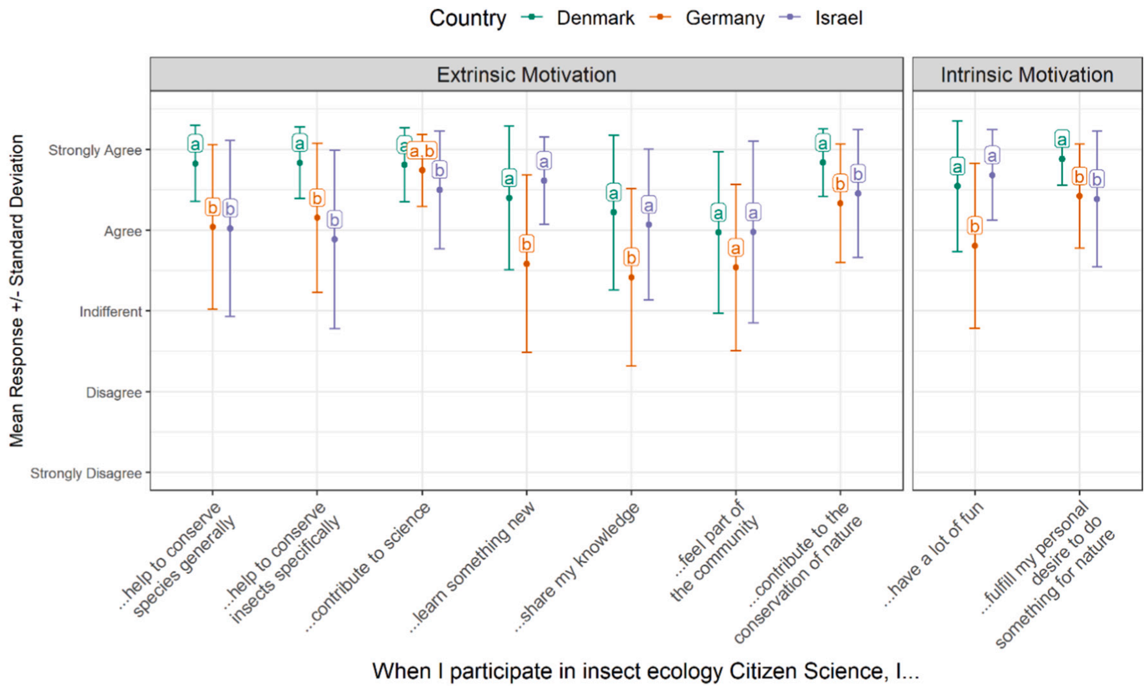

Fig. 2. Mean and standard deviation of agreement level with extrinsic (right) and intrinsic motivations (left), by country. Countries sharing a letter (a or b) label do not have statistically different results.

4.2. Motivations of citizen scientists between and within international citizen science projects

Within each country, both intrinsic and extrinsic motivations were important to respondents, with around half of all respondents (≥54%) agreeing or strongly agreeing with all items (Fig. 2, Table S2). There were, however, significant differences between the countries (Fig. 3). In the Danish project, the most important motivation was the intrinsic

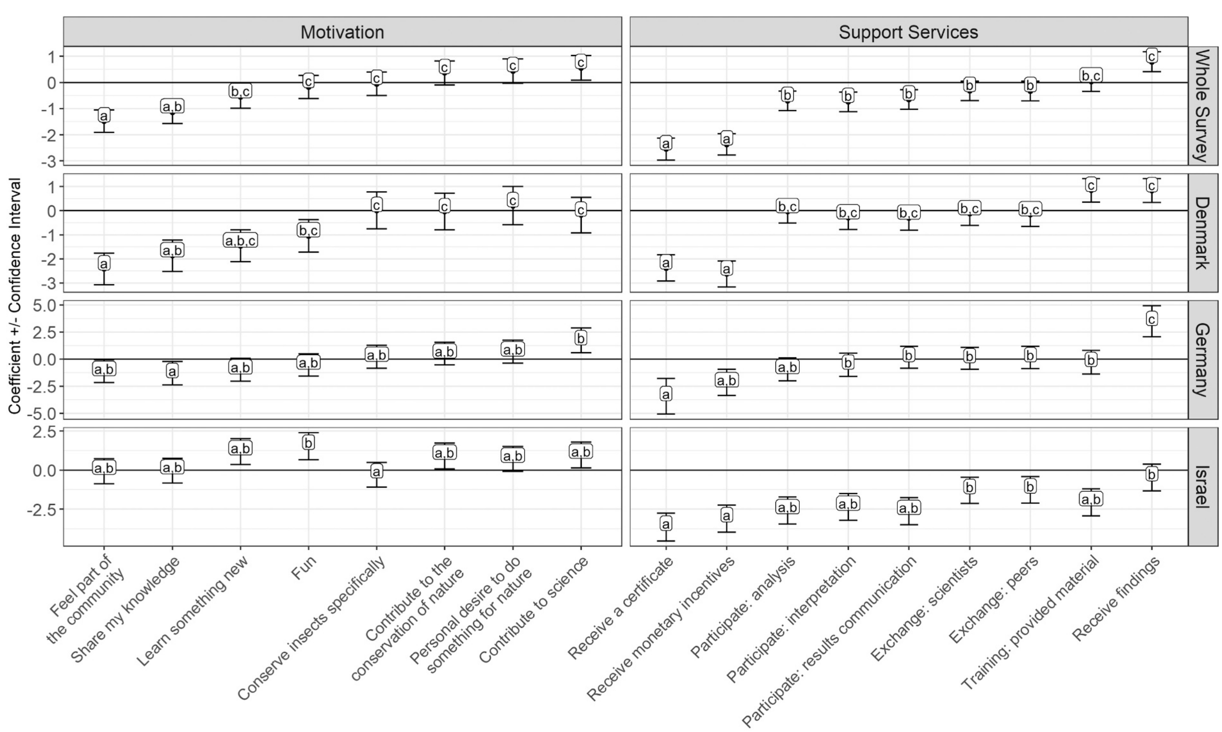

Fig. 3. Ranking the relative importance of motivations (left) and support services (right) **within** (and not between) countries, as well as within the whole survey (top row). All motivations were arbitrarily compared to “help conserve species generally „and all support services were arbitrarily compared to “training courses on identifying insects in the field” (i.e. negative coefficients indicate these motivations/support services were less important, and vice versa). Motivations and services sharing a letter label (a or b) are not significantly different. Germany and Israel were compared to Denmark (which was assigned a coefficient of zero), being first by alphabetical order. For example, statements to which German respondents tended to agree more than the Danish respondents received a significantly positive coefficient for Germany, and so on.

motivation to "fulfil my personal desire to do something for nature". The least important motive in Denmark was to "feel a part of the community". In the German project, respondents' main motivation for participating was the extrinsic motivation "contribute to science" and the extrinsic motivation "contribute to the conservation of nature". The least important motivation items for the participants in the Germany project was "have a lot of fun". For respondents in the BMS-IL from Israel, the most important motivation for participation was the intrinsic motivation "have a lot of fun", and the least important motivation was "conserve insects (butterflies) specifically".

4.3. Effects of age, gender and identification skills on motivation

Motivations for participating in citizen science varied with the demographic background of respondents. Female respondents indicated more often than men that they participated in a conservation-based citizen science project to "have a lot of fun" ($p < 0.01$) and "feel part of the community" ($p < 0.01$, Table S2). While age was not found to be a significant predictor in any of the motivations, older respondents were more likely to be motivated to "contribute to the conservation of nature" than younger respondents ($p = 0.09$). Identification skills were significantly associated with the motivation "to share my knowledge" ($p = 0.03$, Table S2), indicating that those with more identification skills were motivated to take part in insect-based monitoring in order to share their knowledge.

4.4. Support services important to participants

For the entire sample, the support service that was assessed as most important for respondents (Fig. 4) was "receive findings". The services of "receive a certificate" and "receive incentives" were consistently ranked as least important across the entire sample. However, the importance of support services varied considerably across projects, with respondents in Denmark placing consistently less importance on support services than participants in the same project run in Germany (Fig. 4). Respondents in Israel and Germany identified "receive a summary of the findings of the study" as the most important service, while in Denmark it was not the most important albeit, still of relatively high importance) (Fig. 4). Training courses in insect identification were marked as important in the BMS-IL project in Israel (Fig. 4). Receiving monetary compensation such as return funds for petrol or receiving a certificate was significantly more important in the BMS-IL in Israel compared to the other schemes (p-value $p < 0.001$, respectively).

4.5. Linking respondents' most important motivation to support services

For the entire sample, the support service of "monetary incentives" was not an important factor to motivate participation. Moreover, "monetary incentives" was negatively correlated with the extrinsic motivations to "conserve species generally" (Spearman's $\rho = -0.18$, $p = 0.025$) and "conserve insects specifically" (Spearman's $\rho = -0.23$, $p = 0.004$) and the intrinsic motivation "fulfil my personal desire to do something for nature" (Spearman's $\rho = -0.19$, $p = 0.024$) (Fig. 5). This suggests that providing monetary compensation may undermine citizen scientists' motivation for participating, or that highly motivated individuals disregard monetary compensation in the context of volunteering engagement. The intrinsic motivation "have a lot of fun" was positively related for the whole survey to the support services "receiving a certificate" (Spearman's $\rho = 0.17$, $p = 0.024$) and "training courses on how to use the provided material" (Spearman's $\rho = 0.16$, $p = 0.038$) (Fig. 5). The extrinsic motivation "contribute to science" was positively correlated with support services were "participate in results communication"; (Spearman's $\rho = 0.19$, $p = 0.018$) and "participate in result interpretation" (Spearman's $\rho = 0.24$, $p = 0.001$). We found that the relationships between motivations and support services varied among countries.

In Denmark, the support service "training courses on insect identification" was correlated with the most important intrinsic motivations "fulfil my personal desire to do something for nature" (Spearman's $\rho = 0.18$; $p = 0.03$). The support service "training course on insect identification" was also correlated with the several extrinsic motivations such as "contribute to the conservation of nature" (Spearman's $\rho = 0.33$, $p <$

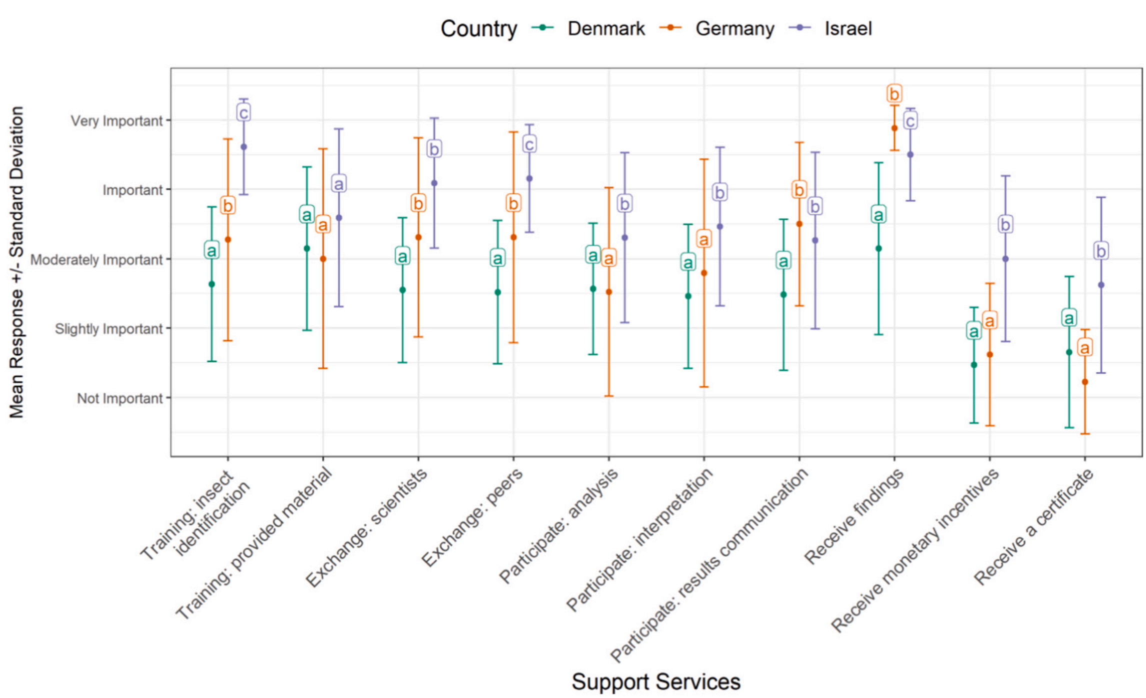

Fig. 4. Mean and standard deviation of importance level (from not important to the very important y-axis) against listed support services (x-axis), by country (colour schemes). Countries sharing a letter label do not have statistically different results. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

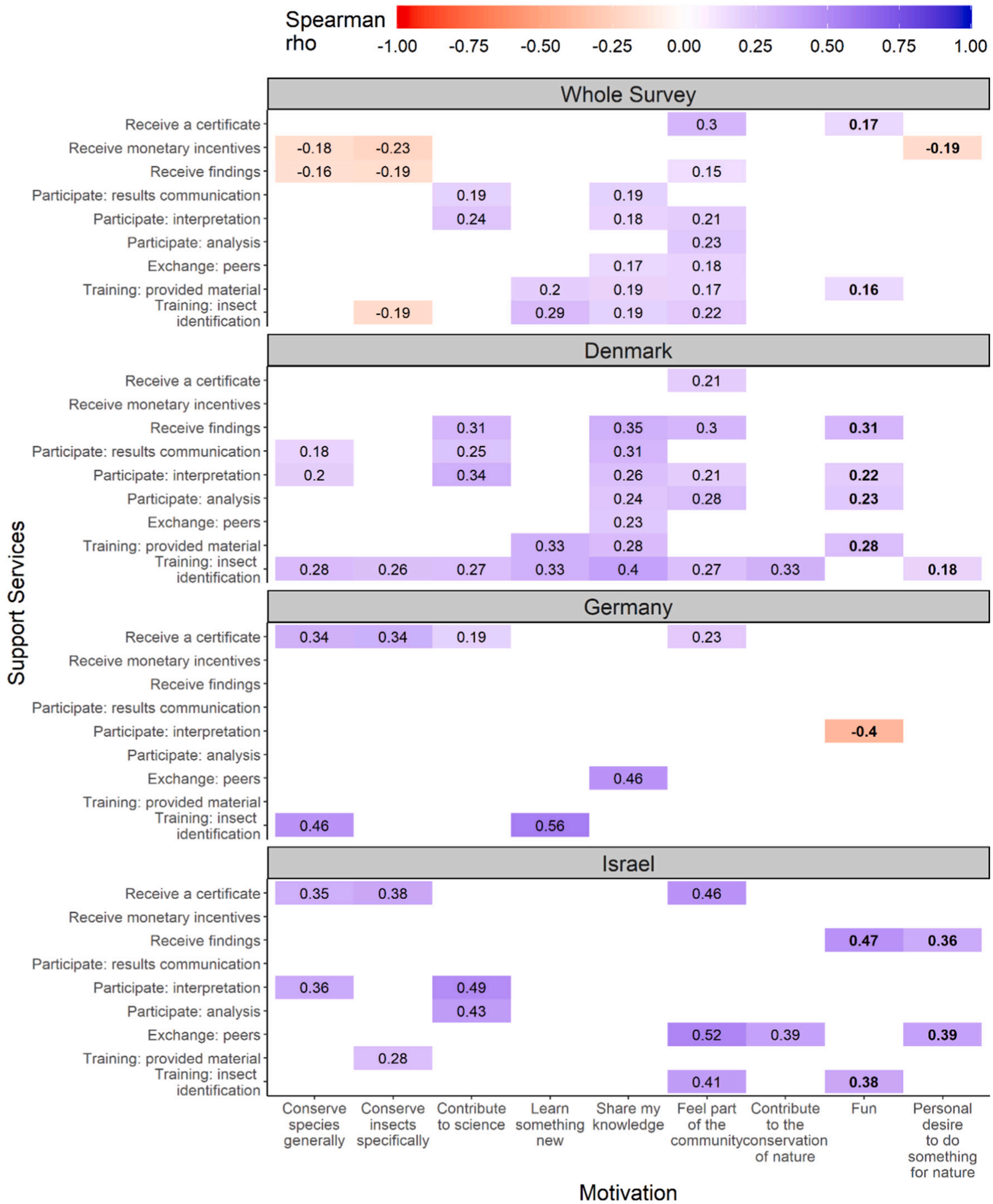

Fig. 5. Significant correlations between motivations (y-axis) and support services (x-axis), for the whole survey (top) and for each country. Numbers in boxes show the Spearmann coefficient with colours of the boxes indicating negative correlations (red and minus) and positive correlations (purple). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

0.001), “conserve insects specifically” (Spearman’s $\rho = 0.26$; $p < 0.001$) and “conserve species generally” (Spearman’s $\rho = 0.28$; $p = 0.001$). Further, Danish respondents indicated that their extrinsic motivations to “contribute to science” was also related to the support services of “participating in data interpretation” (Spearman’s $p = 0.34$; $p < 0.001$) and to “receive findings” (Spearman’s $p = 0.31$; $p = 0.002$) (Fig. 5).

In Germany, the support service “training in insect identification” was correlated with the main extrinsic motivation “conserve species generally” (Spearman’s $p = 0.46$; $p = 0.029$) and the service” receive a certificate” correlated with the extrinsic motivation “conserve species generally” (Spearman’s $\rho = 0.34$; $p = 0.002$) and with the motivation “conserve insects specifically” (Spearman’s $p = 0.35$; $p = 0.001$). The main intrinsic motivation “fulfil my personal desire to do something for nature” was not related to any support service, the intrinsic motivation “have a lot of fun” was negatively related with the support service “participation in data interpretation” (Spearman’s $p = -0.40$; $p = 0.04$) (Fig. 5).

In Israel, the most important motivation for participation was the intrinsic motivation “have a lot of fun”, which was correlated with the support services “receive findings” (Spearman’s $\rho = 0.47$; $p = 0.017$) and “training courses on insect identification” (Spearman’s $\rho = 0.38$; $p = 0.034$) (Fig. 5). Respondents from Israel reported that extrinsic motivation of "contributing to science" was related to two support services, namely "participation in data analysis" as well as "participation in data interpretation" (Spearman's $p = 0.43$; $p = 0.022$; Spearman's $p = 0.49$; $p = 0.016$). Despite the linkages for the most important motivation and project support services, also less important reported motivation showed strong linkages with support services. For example, in Israel the extrinsic motivation of "feeling part of the community" was strongly linked with the support service of "receive a certificate" (Spearman's p = 0.46; $p = 0.004$) or with the support service "exchange with peers" (Spearman's $p = 0.52$; p = 0.001) (Fig. 5).

In short, despite the similarities of the projects (Germany and Denmark) and groups of participants (experts in Israel and Germany), same motivations (e.g. "help conserve insects specifically") were related to different support services (e.g. "training courses on insect identification").

5. Discussion

In our analysis, citizen scientists participating in insect conservation projects were strongly motivated by a range of motives, with the strongest agreement to the extrinsic motivations to contribute to science and nature conservation, and the intrinsic motivations to do something (good) for nature, and have fun whilst taking part in a citizen science activity. These findings concur with previous findings: there is a strong desire in to be driven by self-directed and/or altruistic motives (Kragh, 2016) among participants in citizen science projects focusing on environmental monitoring, such as supporting science (Davies et al., 2011, Hobbs and White, 2012), learning about the environment (Bell et al., 2008) and enjoying the company of like-minded people (Asah and Blahna, 2013) and social experience (Bell et al., 2008). The majority of participants in our study considered a mixture of motives as important for their engagement indicating that citizen scientists' motivations are multifactorial and complex, rather than a single explanation such as connectedness to nature as a proposed predictor of ecological behaviour (Mayer and Frantz, 2004) or the relationship between values and environmental concerns (Schultz, 2001). Overall, multifactorial variables including individual features such as personal attributes and circumstances and personal experiences seem to be important to the motivation of participants (see O'Brien, 2010). The most important support service respondents wanted from their citizen science projects was feedback as to the findings of the study in which they participated. Monetary incentives were consistently ranked as the least important among all respondents.

5.1. Citizen scientists want to contribute to science and help nature

Project designs rarely recognize, address or adapt to the diversity of motivations of their participants in the early phases of project development (Geoghegan et al., 2016). The citizen science goals of the projects are often identified from a purely scientific perspective, despite the calls to "know your audience" (Robinson et al., 2013; Tweddle et al., 2012). Our study shows that citizen scientists, across three culturally different countries, are both intrinsically and extrinsically motivated to engage in insect-focused citizen science projects by a personal desire to do something for nature and to contribute to science.

In this context, our results with respect to citizens' motivation "to contribute to conservation of nature" is highly important. Citizen science- based monitoring schemes often rely on citizens mainly as observers, or providers of data, rather than inherent part of the scheme or communicators of its results. Empowering citizen scientists to act toward nature conservation can be achieved by various means, such as offering citizens the opportunity to act as multipliers or ambassadors of the program, to communicate their knowledge or the project's outcomes – as individuals and collectives - to other citizens, to authorities and decision makers (Haywood et al., 2016); or to participate and ignite conservation action (Gray et al., 2017). Deeper participation may not only improve participants' sense of ownership and motivation to engage further, but also enhance the visibility of schemes, and their potential impact toward their key goal – namely to inform decision makers and the public of the state of nature, and use knowledge and evidence to promote nature conservation on the ground. A more participatory approach, which explores how to enhance not only participants' knowledge but also their capacity to take actions (Ballard et al., 2017), may contribute to capacity building in a broader sense, and can contribute to the much-needed expansion of such programs.

In regard to the motives, we found that all citizen scientists reported a range of both intrinsic and extrinsic motivations for participating (Fig. 2), a finding also reported by Larson et al. (2020). This finding has consequences for the design of monitoring programs supported by citizen science. Successful citizen science projects depend on highly motivated participants. Thus, it is highly valuable to know from the beginning to the end of the monitoring program the status of individual motivation as well as shared and different motivations among the participants. Our results provide evidence that motivations differ among individuals and across schemes- even with shared aims, protocols and procedures involved. Some of the motivations were universal, across projects and countries. From this it is concluded that the focus of these universal motivations might be a good place to start designing a project. Projects will be most successful if they are tailored to meet the specific motivations of its participants (Wright et al., 2015).

5.2. Diversity matters and enriches

Motivations also differed across demographic backgrounds of the participants. One of the strongest factors impacting the motivation of participation was found to be gender. This finding contrasts with findings from Alender (2016) who found no variation in gender but did find age-based variation in motivations for participating in water quality monitoring citizen science. However, as motivations differ between individuals (Clary et al., 1996), we propose for further studies, and urge project designers, managers and coordinators to consider how the project's design suits the cultural, social, and economic backgrounds of (potential) participants (Roy et al., 2012a, 2012b). The long tradition of biodiversity citizen science, here referring mainly to the North American and European citizen science and excluding traditional knowledge and technological citizen sciences, offers some insights about the diversity of participants in citizen science. Currently, citizen science participants are disproportionately white, older, and male (Theobald et al., 2015; Burgess et al., 2017; Edwards et al., 2018). A better understanding is needed of the motivations of the diverse potential participants who are underrepresented in citizen science.

5.3. Importance and links between project support services and volunteers‘motivations

In line with the growth of citizen science and the experiences collated within citizen science, a range of guidelines for citizen science are in place to support the development of citizen science (García et al., 2021). Project features such as the set of support services provided to participants are expected to be critical for long-term engagement of the participants and also set out as one of the ten principles of citizen science (Robinson et al., 2018). These support services include feedback on individual and community performances and/or the application of instruments of communication and appreciation for volunteers and scientists involved in the project. He et al. (2018) showed that positive and direct feedback provided to the participants had a greater impact on the participants' motivation and efforts than did positive feedback alone. Our findings highlight the importance of specific support services such as providing feedback to the volunteers as well as similarities and differences in preference of support services between citizen science projects and among countries. Sharing feedback of project results was identified as highly important, regardless of project or country. The value placed on other support services, however, differed among countries. In the Israeli Butterfly Monitoring Scheme, with the most demanding protocol in our study (Table 1), respondents placed high importance on all support services. Responses from participants in 'The InsectMobile' project, revealed interesting differences in respect to the importance of support services. The respondents from Germany placed higher importance on all support services compared to respondents in the same project in Denmark.

Interestingly, designed cross-country citizen science schemes are rarely implemented or reported in the citizen science landscape. In conservation-based citizen science, observation platforms such as iNaturalist are used by an international community and could be a source of information regarding the support services needed for future engagement. International funding schemes, such as those provided by the European Commission, will potentially further foster cross-country citizen science for topics related to conservation aspects in different sectors, such as adaptation to climate change including societal transformation, smart cities or soil health and food systems. Understanding effective support services in citizen science will be important to the success of these future schemes.

5.4. Monetary incentives

As part of the investigation about support services important for the volunteers, the role of monetary compensation in citizen science appeared. Monetary incentives (e.g. petrol costs for driving) were found to have low importance across all three projects. This could be related to the socio-demographic and educational backgrounds of our respondents (for whom the petrol costs might not have been a hardship, for instance), but these variables were not measured in our study. However, the identified negative correlation of monetary incentives in this study with other motivations may indicate that providing monetary incentives may not support the motivations of those who participate in insect-based conservation citizen science. We showed that monetary incentives were significantly more important in the Israeli Butterfly Monitoring Scheme than in 'The InsectMobile' projects. This suggests differences in the two types of projects. Participation in the Israeli Butterfly Monitoring Scheme requires greater time and effort compared to 'The InsectMobile' project, as of the Israeli Butterfly Monitoring Scheme are required to go out to the field and walk a constant transect twice per month, while participants of 'The InsectMobile' project were only required to drive their cars on only twice in a single summer (June–July). While there are suggestions, that monetary rewards may lead to crowding out of intrinsic motivation (Carpenter and Myers, 2010; Ezzine-de-Blasa et al., 2019), an Italian based survey of volunteers in social care and education services by Fiorillo (2011) showed that both monetary payments and intrinsic motivations can be complementary and may be important for real-life decisions. In other fields such as medical research it has also been shown that participant's motivation for participation can be closely linked with modest monetary incentives (Tishler and Bartholomae, 2002). Personal experiences by the authors of this research in their role of initiator and coordinator of citizen science projects is that monetary compensation can also hamper the efforts of establishing a long-term project since it creates dependency (on such payments) and risks of inequity – where people that are not paid will avoid participate if others are paid. We suggest further discussions about the role of monetary incentives as well issues such as inclusiveness and equity in citizen science e.g. as part of co-designing processes within citizens science and the practice of citizens science. The differences shown in our research in how participants in different projects valued support services again highlight the need for citizen science projects to know the motivations and support needs of their participants.

5.5. Limitations and outlook

Overall, our research reveals that motivation in citizen science-based insect conservation is complex and linked to variables beyond demographic information and support services provided within the schemes. The intrinsic motivation of "fun" or enjoyment as a reason for participation is most likely related to the voluntary nature of the activity. However, this motivation needs further investigation, e.g. through qualitative interviews so as to understand what "fun" means to participants and how it might be featured in projects. Also, the interpretation of the findings of linking motives and support services is limited to the support services selected for our research that were based on those provided by the projects and identified in previous literature. Qualitative research (e.g. focus groups with volunteers) is needed to further investigate the role of support services, including the analysis of the kind of support services needed and wanted by the volunteers. Project features not covered as support services in our study (e.g. spatial and temporal dimension of the projects, language used in the schemes or the complexity of the task involved) may also have effects on the selection of motivation and can be the objective of future research. For 'The Insectmobile' project we are not able to evaluate if the absence of a private car, driving eligibility or opinions on mobility were for participations as owing a roadworthy car was communicated as a pre-requisite right at the start of the project.

The motives investigated here were based on theoretical grounds and derived from previous research. Hence, motive diversity might be only partially captured in our questionnaire. Open questions about additional motives were not allowed and therefore, motives of potentially high importance for people's participation could have been missed. Despite the high relevance for motivation research in citizen science, as previous study we were also not able to get information about motivations from those who resigned from the projects or rejected the invitation for participation in the first place. Future research related to motivation in long-term monitoring schemes provide ideal settings to address this important aspect of non-participation and are complementary to motivation for participation.

Also, it is not known what sets of individual competencies beyond (e.g. digital competencies, scientific literacy, communication skills) and experiences with other monitoring schemes were brought into the schemes by our participants. It remains unclear from our study, how motivation is affected by additional individual skills and experiences of the volunteers. We also acknowledge that universal motivations might be strongly affected by encouraging coordinators and communicators as well as good sampling season. To all our knowledge, no empirical evidence exists about the relations between motives and unfavorable sampling conditions (e.g. adverse weather, unexpected personal changes, a global pandemic). Shifting priorities and motivations from participating in citizen science for science to experience nature for recreational purposes are objectives of future investigations in nature conservation of high importance (e.g. Marselle et al., 2021; Ganzevoort and van den Born, 2019; Koss, 2010). Finally, our investigation is based on correlative analysis and should be further tested in experimental designs. Specifically, linking motivations and support services would benefit from experimental evaluations of citizen science projects.

Despite these limitations, we believe that understanding the associations between participants' motivation and support services as well as acknowledging the heterogeneity of motivation within and among projects can inform better citizen science project design and management in conservation sciences. Project coordinators will benefit from a prior assessment and understanding of their target citizen scientists' perspectives for project design and management. As we have shown receiving feedback and recognition is crucial to foster retained participation (see also Land-Zandstra et al., 2016; Mulder et al., 2010), and the long- term engagement of volunteers will be determined by the use of data and results generated by the participants as shown for online citizen science (Nov et al., 2014) as well as strong social networks (Richter et al., 2018). Participating in citizen science can not only lead to data generation for conservation action that may not be available otherwise, but also strengthen personal learning and environmental stewardship by participants (Turrini et al., 2018) and thereby foster long-term support for conservation.

Applying the Self Determination Theory in our research enabled us to identify the imbalance of support services for the fulfilment of intrinsic and extrinsic motivation. Without such understanding, some schemes relying on the engagement of participants could fail (Roy et al., 2012a, 2012b) and lead to poor recruitment or high exit rates in the schemes (Wright et al., 2015). We conclude that prompt and clear communication of the findings and the provisioning of training for participants are important for continued involvement in citizen science-based monitoring. Cultural effects were identified (see Rotman et al., 2014), and thus, we recommend that international standardized schemes of biodiversity monitoring consider adaptations for country specific design and management in volunteer management that address the specific cultural background affecting citizens' motivation. Accordingly, international citizen science programs need to tailor their respective country specific support mechanisms to activate, train and retain participants. Overall, in the quest to understand the complexity of motivations and the importance of different backgrounds of participants in citizen science, interdisciplinary collaborations between behavioral psychologists, social scientists and conservation scientist will advance contemporary conservation research and practice. Understanding citizen science motivations is needed to address complex conservation challenges such as designing and conducting participatory global biodiversity monitoring to understand and halt insect decline.

Declaration of competing interest

We have no conflicts of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2021.109325.

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