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Evaluating perceptions of STEM majors to explain diversity gaps in entomology and other sciences

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Communities working in entomology, ecology, and other natural sciences are known for having shortfalls in racial and gender diversity. We aim to uncover drivers of this diversity gap. To achieve this, we distributed a survey to undergraduate students at large academic institutions in North America. The survey was designed to profile the perspectives people had about entomology, ecology, and agricultural science compared to other disciplines, and to see if these perspectives differed among demographics (race, gender, and sexual orientation). In addition to soliciting information about general perception relevant to recruitment and retention (approachability, hospitality/how welcoming a field is, fear, importance, interest, job availability), we also asked targeted questions about race-related issues (race motivated violence, racist authority figures, historical racism). In general, we found that race and sexual orientation did not often explain differences in perception of academic fields while gender did. Entomology was perceived the most negatively compared to all other disciplines, largely being driven by a high perception of fear, lack of knowledge about the importance of entomology, and the perception that jobs are lacking in the field. However, LGBTQ+ status predicted a significant increase in the perception of entomology as a "beautiful" science. Perception of race-related issues in ecology and biology differed by demographic, but the effect-size was small. We present several recommendations for higher education based on our results.

Keywords: education, diversity, recruitment, retention, inclusion

Introduction

White, able-bodied, cis-gendered men are advantaged by the North American educational system (Cech 2022), while most other groups have been disproportionately marginalized as a result (Good et al. 2012, Stephens et al. 2014, Li and Koedel 2017). These gaps harm scientific productivity and innovation potential (Hofstra et al. 2020), harm effective mentorship (Estrada et al. 2018) and teaching practices (Harackiewicz et al. 2016, Metzger et al. 2023, Haeger et al. 2024), and most importantly, harm the humans that have been historically excluded.

Using data from National Science Foundation (NSF) and the National Center for Science and Engineering Statistics, we previously identified entomology and ecology as two subdisciplines of biology where white men are the most advantaged (Evangelista et al. 2020). Being entomologists ourselves, we were interested in identifying the drivers of this diversity gap to find recommendations to remediate it. Originally, we gave generic recommendations based on literature (Evangelista et al. 2020), but lacked specific data on entomology, gaps in sexual and gender identity, and recruitment/retention in general. The overarching goal of the present study is to address these issues. The present study addresses 9 major science, technology, engineering, and mathematics (STEM) fields, primarily focusing on entomology, followed by agricultural science, ecology, and biology.

Gender and racial diversity in entomology (Evangelista et al. 2020) and other STEM fields (Blickenstaff 2006, Good et al. 2012, Li and Koedel 2017) is lacking compared to other human demographics. Newer data (NSF 2022) do not show variation from what was previously reported in entomology, despite efforts to increase participation by minoritized groups (eg

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EntoMentos, a mentoring circle that formed in 2021, or Entomologists of Color, EntoPOC, a nonprofit working on recruitment that formed in 2020). Estimates from NSF data from the 2022 and 2024 US Census show people from all racial categories, other than Asian, were underrepresented among STEM graduates. From most underrepresented to least, STEM graduate lists indicate that Indigenous North Americans were 79% underrepresented in proportion to the general population, followed by Latinx (51%), Black (45%), and white (12%), while Asian people were the most overrepresentated (59%). Out of the 88 total entomology graduates reported (NSF 2022), further underrepresentation was observed beyond the general STEM population. Among these graduate students, Indigenous North Americans were not at all represented, followed in underrepresentation by Black graduates (83%), Latinx (59%), Asian people (47%), with whites possessing 3% overrepresentation in entomology. We also identified a gender bias in those employed as entomologists: In 2023 Entomological Society of America (EntSoc) reported 38% of members as female identifying, 53% as male identifying, and 1% as nonbinary. This is lower than the proportion of 2022 degree earners in entomology identifying as women (47.8%), reflecting a "leaky pipeline" or "hostile obstacle course" that negatively impacts retention. This lack of diversity is seemingly in spite of numerous efforts by scientific societies, universities, nonprofits (eg EntoPOC, the Public Health Entomology For All program at EntSoc, the EntoMentos program at EntSoc), and academic departments (eg Cornell university's "Diversity Preview" events) to diversify these fields. Walker (2022) surveyed women in entomology and found that women were entering entomology in lower numbers than their male counterparts, with a continued trend across career trajectories up to full professorship. Additionally, Walker (2022) found that people who identified as men published more papers and higher H-indexes. Broadly speaking, the entomology workforce fails to reflect the diversity of humans in society.

Recruitment of diverse undergraduates into entomology is essential for closing the diversity gap. Indeed, students are known to join entomology from a variety of institutions, but small liberal arts colleges may be particularly important (Banschbach 2016). However, this requires students be recruited from other majors because entomology is rarely offered as an undergraduate major. There are roughly ~500 total entomology undergraduates in the United States (College Factual 2024). Recruitment of undergraduates into entomology is predominantly shaped by their perception of science, and what it means to be an entomologist. Given the varied makeup of entomology faculty in entomology departments nation-wide, perceptions of an entomological profession vary depending on student exposure to faculty research. Research has shown that women and people of color often differ in motivations for entering STEM than white, able-bodied, cis-males (Smith et al. 2014, Quadlin 2021). Entomology, being a hugely interdisciplinary field, could appeal to those populations but demographic data fail to capture these patterns.

In this study, we present a survey of undergraduates with the aim of identifying differences in perception of entomology among demographic groups, and how those perceptions differ compared to other STEM fields. We thus evaluated entomology, agricultural science, biology, ecology, genetics, mathematics and statistics, physics, psychology, and sociology. Specifically, we aimed to assess students' perceptions as it related to the subject matter and content, and the community of people involved with teaching that subject (eg professors, experts, authorities); Eisen (2020) detailed how faculty diversity influences retention of historically excluded students, while Whitehead (2018) showed that family, friends and educators strongly influenced undergraduate major choice in STEM, and Cronin et al. (2021) provided examples of racism in the community of biology.

This study follows Evangelista et al. (2020), designed to identify recruitment and retention drivers of the diversity gap in entomology. This diversity gap potentially derives from several sources. A STEM field's perceived difficulty is important for recruitment, and perception of increased difficulty can be among the strongest predictors of disinterest (Rosenzweig and Chen 2023). If a student sees a certain field as requiring longer times to achieve their degree, this could be a barrier to them entering that field. This, and other finance related career choices, may vary by race, immigrant status, or community (Quadlin 2021, Bravo and Stephens 2023). Higher perceived difficulty could hamper student confidence, which can directly impact their sense of belonging (Dost 2024). Microaggressions (Fitzgerald-Russell and Kowalske 2024), discrimination (Eaton et al. 2020), and lacking a sense of belonging also contribute to lower retention of historically excluded sexual (Fitzgerald-Russell and Kowalske 2024) and racial groups (White et al. 2019, Watkins and Mensah 2022). Recent research suggests that a sense of belonging in STEM is a complex concept with four successive elements, each important for recruitment and retention (Dost 2024). In short, personal interest is important, while feeling safe, respected, valued, included in a community, and receiving support from peers and mentors were all major components to achieve a feeling of "STEM belonging." Finally, as mentioned above, perception of ability to secure employment after a degree also affects how students make career decisions about STEM fields (Bravo and Stephens 2023, Rosenzweig and Chen 2023); although, this may be impeded by a lack of knowledge about job availability (Zahry and Besley 2017).

The present study also aims to address if specific race-related issues could be driving the diversity gap. Evangelista et al. (2020) suggested that the geographical distribution of entomology departments, being mostly at land-grant universities founded on stolen land (Ahtone and Lee 2021, McCoy et al 2021) in white-dominated urban areas, could be a contributing factor. Orfinger (2020) proposed that the history of agricultural slavery (Hunte 1977, Jean-Philippe et al. 2017) could negatively impact entomology recruitment among populations historically affected by slavery. Hunte (1992) indeed showed that negative perceptions of agriculture could be driving Black Americans away from that field. We also examined the perceived impact of racist attitudes among authority figures (eg Eaton et al. 2020) in each STEM field. There is a strong history of racist authority figures in science (eg Nature 2007, Durkin 2019), resulting a plethora of anti-inclusive impacts (eg Moore et al. 2003, Eaton et al 2020, Nguyen and Riegle-Crumb 2021). Finally, we also assessed if potential for race-motivated violence was a determining factor in perceptions of STEM fields.

In addition to the major aims listed above, we addressed secondary aims. For one, literature on inclusion in entomology largely lacks data on gender or sexual orientation. Here, we treat sexual orientation and gender identity equally to racial demographics. Additionally, we wanted to collect preliminary data on the effect of family perceptions and upbringing on entomology. Prior research suggests that familial support is hugely influential for STEM recruitment and retention (Whitehead 2018, Watkins and Mensah 2022, Bravo and Stephens 2023). Similarly, socioeconomic status and upbringing (eg urban vs. rural, affluent vs. low-income housing) may affect one's relationship to nature and agriculture (Jean-Philippe et al. 2017).

Materials and Methods

Design

We designed a survey aimed at undergraduates at major institutions in North America. The undergraduate level is when most students are deciding if they will pursue entomology and similar graduate programs. Pearson (1992) surveyed entomology graduate students and found that most decided they wanted to be scientists by the age of 16, and decided to become entomologists by their early twenties. Our original aim was to better understand inclusion in the field of entomology, so we predominantly surveyed undergraduate students at institutions that had entomology as a major for graduate or undergraduate students. This would make it such that every respondent could, hypothetically, choose entomology classes (or an entomology major) as part of their course of study. We achieved this by obtaining a list of all North American universities offering an entomology program from the EntSoc. Note that entomology is often paired with parasitology or arachnology when offered as a major. Depending upon the institution, entomology is offered as a subdiscipline of agricultural science, or biology.

The survey included four major sections (Supplementary Material). The first section largely solicited demographic information. Specifically, we asked for respondent gender, sexual orientation, race, and ethnicity. We also asked respondents to identify their academic major, their academic career stage (eg undergraduate, graduate, etc.), and provided two multiple-answer questions to identify their career goals. Finally, this first section included one critical "knowledge-check." Since most of the survey (sections 2 and 3) asked about students' perception of academic fields, we needed to ensure each respondent could accurately identify each field. The "knowledge-check" question listed 9 academic fields and asked them to match the name of the field with a definition for that field (Supplementary Material). The second section comprised 11 Likert-style questions on these same 9 academic fields. Each question solicited a perception related to the field: difficulty, safety, importance, relevance, beauty, and job availability. The third section comprised three questions in a similar format to the questions in the previous section. Here, each question asked about their perception of each academic field and if it was influenced by a "race-related" issue. Specifically, the questions asked about the influence of: "risk of exposure to race-motivated violence," "racist attitudes of authority figures," and "history of race-related exploitation" (see Supplementary Material for specific wording). The fourth and final section of the survey included four questions that were marked as optional. These briefly addressed additional hypotheses about the drivers of racial diversity gaps. The questions asked about specific social, and cultural elements of the respondents and their families as they relate to recreation, nature, and agriculture. Each section also included one to two open ended questions where respondents could clarify or expand on their responses. The final survey had a total of 33 items.

Survey Distribution

In order to maximize the diversity of students who would receive the survey, we aimed to target qualifying universities (see above) with the largest student populations in the most and least racially diverse cities based on data from the 2012 to 2016 American community 5 yr survey (U.S. Census Bureau 2016). This allowed us to narrow down the list of all qualifying institutions ($N = 51$) to target a select pool of institutions ($N = 19$) more aggressively. We wanted to target universities in racially diverse cities under the assumption that their students would also be racially diverse. We also targeted some universities in very low racial diversity cities to provide opportunities to give voice to potentially hyper-marginalized student populations (eg members of underrepresented racial groups in communities that are even less diverse than average). We did not aim to get a representative sample of the general population, or a representative sample of undergraduates, as these would not have best served the goals of this study. Instead, we aimed to overrepresent minoritized and historically excluded demographics.

We distributed our survey (hosted by SurveyMonkey) using multiple methods over a 3-yr period (2021 to 2024). In 2021 and 2022 we directly contacted higher administration at eligible institutions, giving more emphasis to priority institutions. We asked the administration at each institution for assistance in distributing our survey to their STEM undergraduates. Also in 2022, we distributed our survey through professional higher-ed networks on Twitter and at the EntSoc national meeting. Here, we directly asked higher-ed teachers to distribute the survey to their undergraduate students if they were at one of our eligible institutions (a link to the list of institutions was provided on the flier we distributed). In 2023 we took four approaches. First, we printed physical fliers with QR-codes linking to the survey and posted them on campus at two eligible institutions (UIUC and Ohio State). Then, in the Summer of 2023, we researched high-attendance classes for fall semester 2023 at some high-priority institutions ($N = 16$), recorded the course name, and identified the email addresses of professors/lecturers at those institutions ($N = 324$). We then drafted two emails to those teachers providing instructions on how to distribute the survey to their students, kindly requesting their help. Third, in Spring 2024 we targeted students in one large course at a single eligible institution. Finally, we requested assistance from the administration at one more eligible institution.

Analysis

Data analyses were done in Mathematica 13.2 (Wolfram Research 2024). To understand the academic motivations and interests of the student population, we analyzed one multiple answer question that asked the respondents to choose items that best describe their career interests. We divided the responses by items that identified motivations and activities interested in and analyzed these by demographic groups. To identify values as significantly lower or higher we did 100 randomizations of the data for each demographic comparison and noted the non-randomized values as significant if they fell outside the middle 90th percentile of the random distribution.

All Likert-scale responses were coded as ordinal numeric data using the same polarity. For example, here is what was done for questions under the factor "perceptions of safety." For the question assessing the perception of how dangerous each academic field was, Likert responses were coded in the following way: "Very dangerous" = 3, "Moderately dangerous" = 2, "Little danger" = 1, and "No danger" = 0. Another question assessing the perception of how safe each academic field had Likert responses coded in the following way: "Very unsafe" = 3, "Moderately unsafe" = 2, "Moderately safe" = 1, "Very safe" = 0. The same numeric range (0 to 3) was always used, and more positive perceptions were always coded as lower numbers and more negative perceptions were coded as higher numbers. Each question also included a "No opinion" option. All the plots were made using the Likert: Analysis and Visualization Likert Items in R.

For all Likert analyses, we utilized the mean response for both individual questions, and for pooled questions that contribute to a larger category (Table 1). To create the larger categories, we simply pooled all responses for individual questions in that category as if they had been a single question. For all statistical comparisons we set an alpha cutoff of 0.001 for determining significance. Rather than treating "No opinion" responses as neutral, we interpreted them as respondents abstaining from answering the question and did not consider them in any analysis.

Statistical Validation

We used a factor analysis to validate the issues assessed by the survey. The factor analysis utilized an ordinal logistic regression (generalized linear model with a logit link function) to calculate the correlation between factors. We utilized Efron pseudo-R^2 (Efron 1978) values as the correlation statistic. For each higher category, we confirmed that the factors in that category correlated more strongly with other factors in that category than factors outside of that category. We also found that factors 2 (perception of how welcoming) and 11 (perception of job availability) did not correlate strongly with any other factor. Then, to better understand the "total perception" category, we calculated correlations between all subcategories and total perception. This showed total perception most highly correlated with personal interest and perceived importance of the field of study.

Hypothesis Testing

We used pairwise Mann–Whitney Tests to compare responses among two factors (eg Black vs. white respondents, or straight vs. LGBTQ respondents) and analysis of variance (ANOVA) when comparisons were done among more than two factors (eg all races vs. all other races). We omitted any groups with a sample size of less than 20, except when that group could reasonably be lumped into a larger group. For instance, only 13 respondents identified as transgender. Rather than drop the respondents, we analyzed the results two ways: first by lumping trans respondents into the nonbinary gender group (total $N = 41$), and second by lumping trans respondents into the gender they identified (total $N_{\text{females}} = 398$, $N_{\text{males}} = 209$). This decision offered a robustness check by testing the effect of gender identity in two ways. The former method would be more likely to estimate (externally originating) effects of discrimination against gender nonconforming people and the latter would be more likely to estimate the effects of sexist bias, both implicit and explicit (eg see Harper [2012] on including oppression as an interpretation of significant demographic differences). To achieve similar aims, we also aggregated data from all non-white participants into a combined "POC" group (a.k.a., People of the Global Majority). In both cases, this served as a robustness test, allowing us to assess the sensitivity of results to changes in the analysis. Finally, we also compared each field of study without disaggregating the data by demographic factors using ANOVA.

Table 1. Perception categories used in our survey design and analysis

Question	Addresses perception of field …	Contributes to a larger category…	Contributes to a larger category…
1	Difficulty	Approachability	Total perception
4	Intimidation		
2	Welcoming	Welcoming/ Hospitality	
3	Danger	Fear	
5	Safety		
6	Societal importance	Importance	
7	Community relevance		
8	Career relevance	Total interest	
9	Personal interest		
10	Beauty		
11	Job availability	Job availability	

Results

In all, we received 643 responses to the survey. Typical completion time for the survey was 13 to 18 min. Considering only the direct emails to course leaders (Fall 2023 collection effort), we received an average of 0.36 student responses per person (eg professor, teaching assistant, lecturer) we contacted. We manually removed one respondent for not answering the demographic answers honestly, and filtered out non-undergraduate students and respondents who got less than 6 of 9 knowledge check questions (to ensure they could correctly identify the fields of study we compared). This resulted in a final pool of 540 responses to analyze.

Describing the Respondent Population

Survey respondents (Fig. 1) were predominantly European, with over 300 individuals identifying as such. Over 50 people identified as multi-ethnic/mixed. Over 50 respondents identified as East Asian, ~30 identified as South East Asian, and over 50 respondents identified as South Asian. Those identifying as Indigenous included ~30 respondents who identified as Indigenous North American, fewer than 10 who identified as Indigenous Australian, and more than 30 people identified as Indigenous South or Central American. Fewer than 10 people identified as Pacific Islander, or Malagasy, ~20 people identified as Sub-Saharan African, and ~30 people identified as Middle Eastern or North African.

Sexual orientation and gender demographics of the respondents were as follows. All gender identities reported were: female ($N = 393$), male ($N = 201$), nonbinary ($N = 28$), trans-female ($N = 5$), and trans-male ($N = 8$). All sexual orientations reported were: heterosexual ($N = 426$), gay/lesbian ($N = 34$), pansexual ($N = 25$), bisexual ($N = 95$), and queer ($N = 25$). Forty-four respondents indicated "other" as their gender identity or sexual orientation, and these respondents were omitted from comparisons between gender demographics.

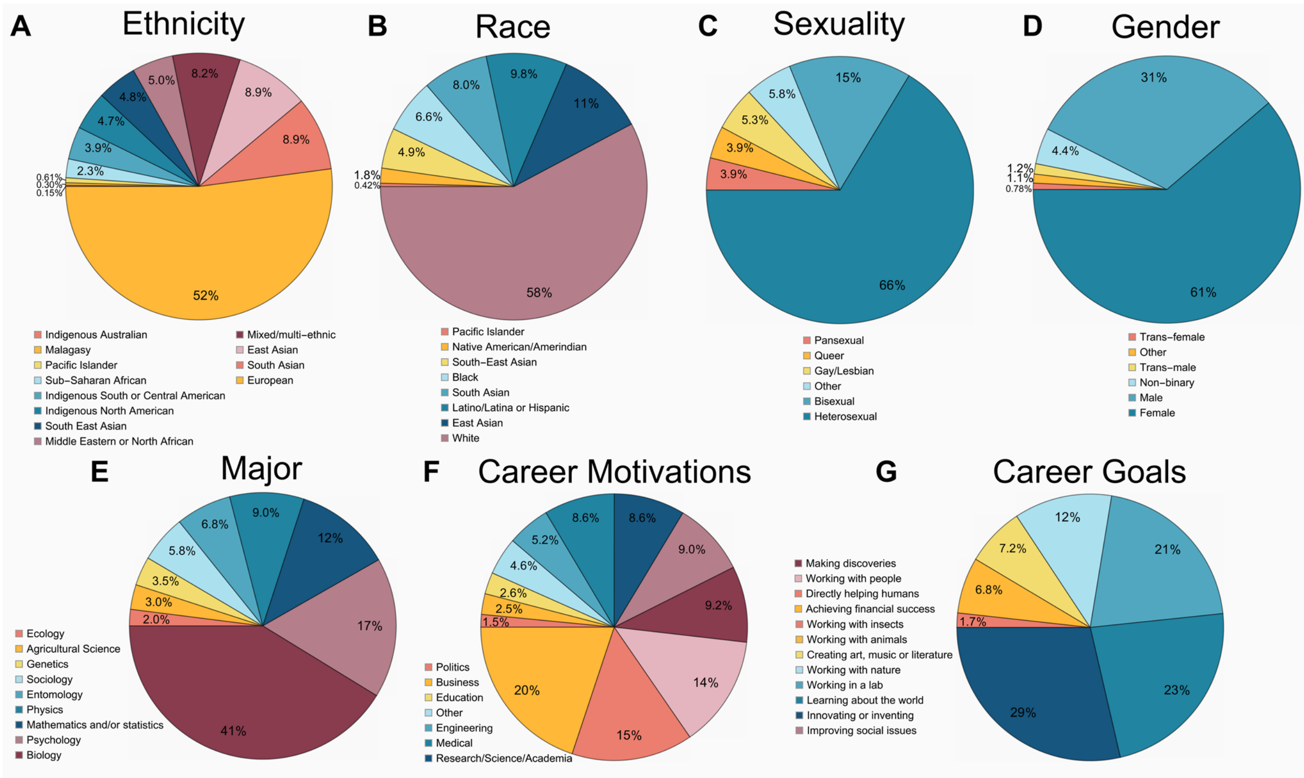

Fig. 1. Demographics of the respondents (N=642) to our survey. Legends for each pie chart are shown below or left of the corresponding chart. Legend items (and pie slices) are ordered from smallest percentage of the population, to largest. The demographic elements shown are (A) ethnicity, (B) race, (C) sexuality, (D) gender, (E) academic major, (F) career motivations and (G) goals.

The largest proportion of respondents (Fig. 1) were biology majors (>150 people), with the next most common major being psychology (~70 people). Majors do not always reflect the long-term career goals of individuals, so we also asked the respondents about their career goals. Over 160 people responded that they intend to enter research/academia, ~120 people intend to work in engineering and ~130 people responded that they hope for careers in medicine. Roughly 40 survey respondents sought careers in business, and ~40 seek careers in education. A smaller proportion of the respondent pool seeks a career in politics (<10 people), and for many of the respondents, their ideal career choice was not one of the categories we provided (~70 people). Only 20 people indicated that they seek a career working with insects, while ~25 sought a career working with other noninsect animals. Virtually all respondents replied that they seek to achieve financial success or stability, with ~300 hoping to directly help humans and/or work with people.

Table 2 shows the proportion of respondents indicating some of the above career motivations and career interests of respondents by demographic. Note that these data come from a single multiple-choice question in the survey that allowed multiple responses.

Career motivations of non-LGBTQ males were not significantly different than as expected from randomness, while non-LGBTQ females and LGBTQ people were motivated by altruism and social improvement ("Directly helping humans," "Improving social issues") significantly more often, and non-LGBTQ females were motivated by creativity less often. Black respondents were also more likely to indicate altruism or social improvement ("Directly helping humans," "Improving social issues") as their career motivation, while white respondents were less often motivated by creativity. Latinx and the "all POC" group (all non-white respondents) were not significantly different from the null expectation.

In choosing career interests, LGBTQ people less often reported an interest in working in the lab and instead more often reported an interest in working in nature. LGBTQ was also the demographic that indicated, with the highest frequency, an interest in working with vertebrates or insects, but it was not significantly higher than the null. On the other hand, non-LGBTQ males and females were interested in working with people significantly more, and non-LGBTQ females were less often interested in working with insects. Black respondents most likely to indicate an interest in working with people but the least likely to indicate an interest in working with animals and insects (all statistically significant). In fact, no Black respondents indicated an interest in working with insects. Other racial demographics showed no significant differences from the null.

Comparison of Academic Fields

Among 521 respondents, entomology was perceived the most negatively (mean response = 1.74) compared to other fields of study, with agricultural science (1.57), physics (1.47), and ecology (1.36) more negative than the average (1.26). The most positively perceived fields of study were biology (0.85), genetics (1.01), and psychology (1.05). The differences between the most negatively, and positively perceived was significant ($P < 0.0001$).

Table 2. Comparison of motivations and academic interests in higher education by demographic[a]

	Element	Black	Latinx	All POC	White	Non-LGBTQ Female	LQBTQ	Non-LGBTQ Male
Motivation to be in higher education	Financial	28.40%	32.90%	27.00%	27.70%	28.90%	26.20%	26.80%
	Altruistic or social improvement	39.5% (+)	28.20%	32.10%	33.00%	35.7% (+)	35.2% (+)	25.30%
	Curiosity	19.80%	25.90%	23.60%	25.30%	23.90%	23.90%	26.00%
	Creativity	12.40%	12.90%	17.30%	13.9% (–)	11.4% (–)	14.70%	22.00%
Academic interests	Lab	14.80%	18.20%	18.80%	19.30%	20.60%	17.32% (–)	18.60%
	People	66.67% (+)	60.60%	52.70%	47.30%	54.6% (+)	38.00%	56.8% (+)
	Vertebrate Animals (nonhuman)	3.7% (–)	6.10%	8.90%	9.30%	9.20%	11.70%	5.10%
	Nature	14.80%	12.10%	15.20%	17.70%	12.20%	24.14% (+)	12.70%
	Insects	0% (–)	3.00%	4.50%	6.40%	3.4% (–)	7.80%	5.10%

[a]Parentheses indicate values significantly outside the 90% confidence interval and sign indicates if it was above (+) or below (–) the middle of the null distribution generated in 100 randomization trials.

Figures 2 and 3 compare perception of each academic field by subcategory. Entomology was the most negatively perceived in terms of respondents' personal interest, fear, job availability, danger, and safety (all P-values <0.0001). Entomology was never the most positively perceived in any subcategory, but it was more positively perceived than average in terms of difficulty (ie, was viewed to be easier), hospitality (ie, was perceived to be more welcoming), and intimidation (ie, was viewed to be less intimidating).

There was a strong effect when considering the impact of racial issues on overall perceptions of each academic field ($N=509$). Perceptions of genetics (1.20), psychology (1.22), and sociology (1.23) were all strongly affected by racial issues, whereas entomology (0.60), ecology (0.72), physics (0.78), and math (0.81) were reported to be much less affected than average (0.97; $P<0.0001$).

Perception of Academic Fields by Demographic

Race

Respondents' race was not significantly related to perception of academic fields overall, or in the subcategory and "total interest", "approachability", or "job availability" (Table 3). Genetics was viewed with high fear by Black respondents (1.49), and low fear by white respondents (1.09) ($P=0.0002$). Biology was viewed with high fear by South East Asian respondents (1.33) but low fear by white respondents (0.89) ($P=0.0005$). Agricultural science was viewed as less important (than other academic fields) by South East Asian respondents (0.76) when compared to other racial groups, and more important than other academic fields by Black respondents (0.41) when compared to the respondents of other racial groups ($P<0.0001$).

We repeated this analysis after aggregating all non-white respondents into a POC category (Table 4). The results were very similar with the exception that POC respondents also viewed entomology higher in fear (1.22) than white respondents (0.98; $P=0.0002$).

Gender

Respondent gender was statistically related to respondents' perceptions of academic fields (Table 5). In the first analysis we put trans and nonbinary identifying respondents together into a "gender nonconforming" category. Male respondents viewed biology, genetics, psychology, and sociology more negatively than other disciplines whereas female respondents viewed those same fields more positively (all P-values < 0.001). Female respondents viewed physics, and math negatively compared to other disciplines, while male respondents viewed those fields positively (all P-values < 0.001). Gender nonconforming students viewed all fields roughly neutrally, or more negatively than the mean (all P-values < 0.001). Agricultural science only showed gendered differences in perception in the fear category, where gender nonconforming students viewed it more negatively (1.88) than males (1.13; $P<0.001$). There were no gendered differences in the perception of entomology, or ecology. In a second analysis, we put trans respondents into the gender they identified with. This had no effect on the statistical significance of male, female, or nonbinary respondent preferences.

Sexuality and LGBTQIA+ Status

Respondent sexual identity or LGBTQIA+ status had little effect on overall perception of academic fields. However, when respondents were lumped into two categories (heterosexual and LGBTQIA+) there were some differences in perceptions. LGBTQIA+ respondents perceived physics (1.75) more negatively than heterosexual respondents (1.36, $P=0.0001$). LGBTQIA+ respondents viewed entomology (1.06) more as more "beautiful" than heterosexual respondents (1.52, $P>0.0001$) but less approachable (1.54 vs. 1.31; $P=0.0002$). Note that this second test also addressed gender, as nongender conforming respondents were included in the LGBTQIA+ category. When all sexual identities were treated separately, no comparisons were significant.

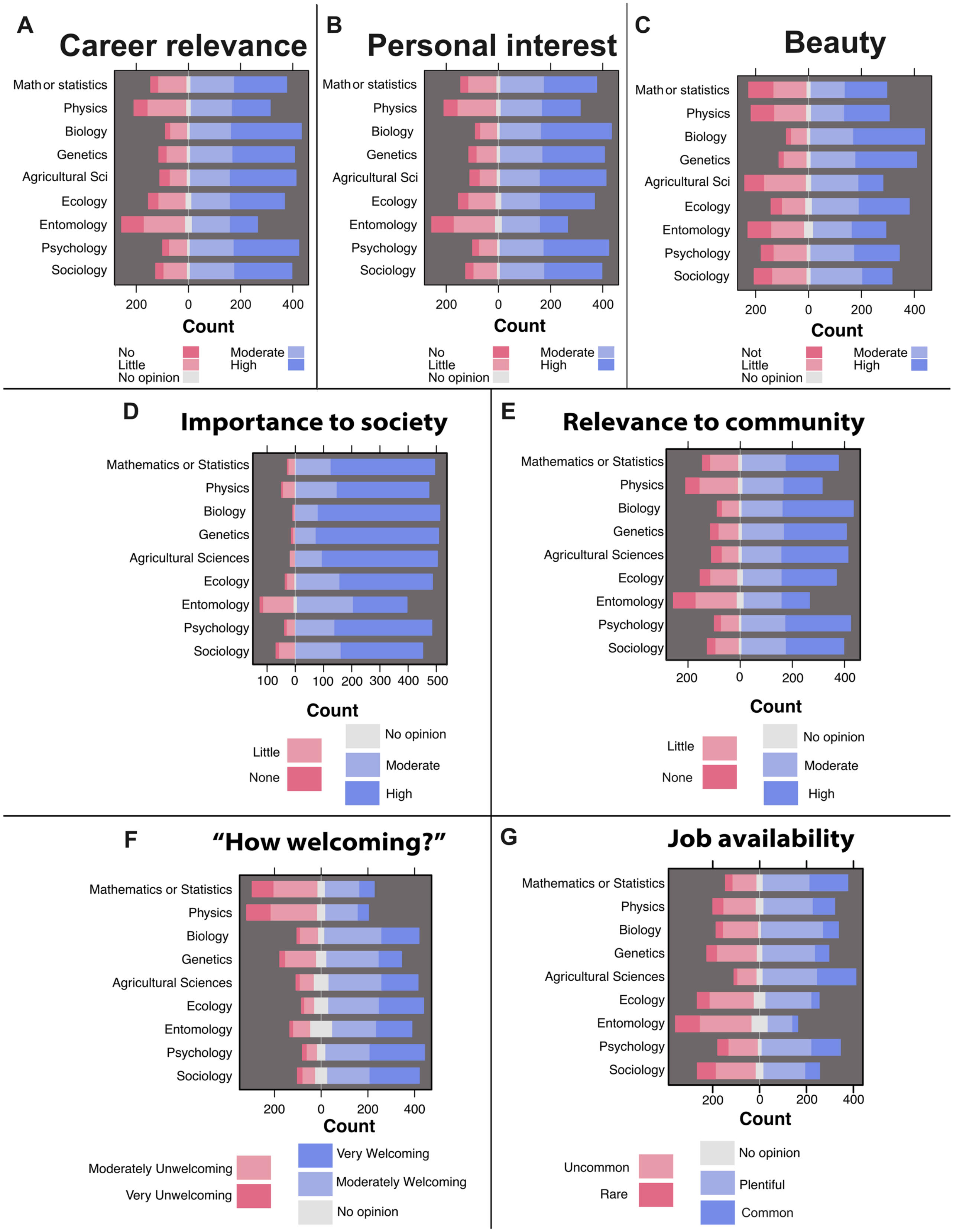

Fig. 2. Perceptions of academic fields in four categories: A–C) total interest, D, E) importance, F) hospitality, and G) job availability. The horizontal bars show how many respondents gave each level of response for each academic field. See Fig. 3 for remaining perceptions quantified.

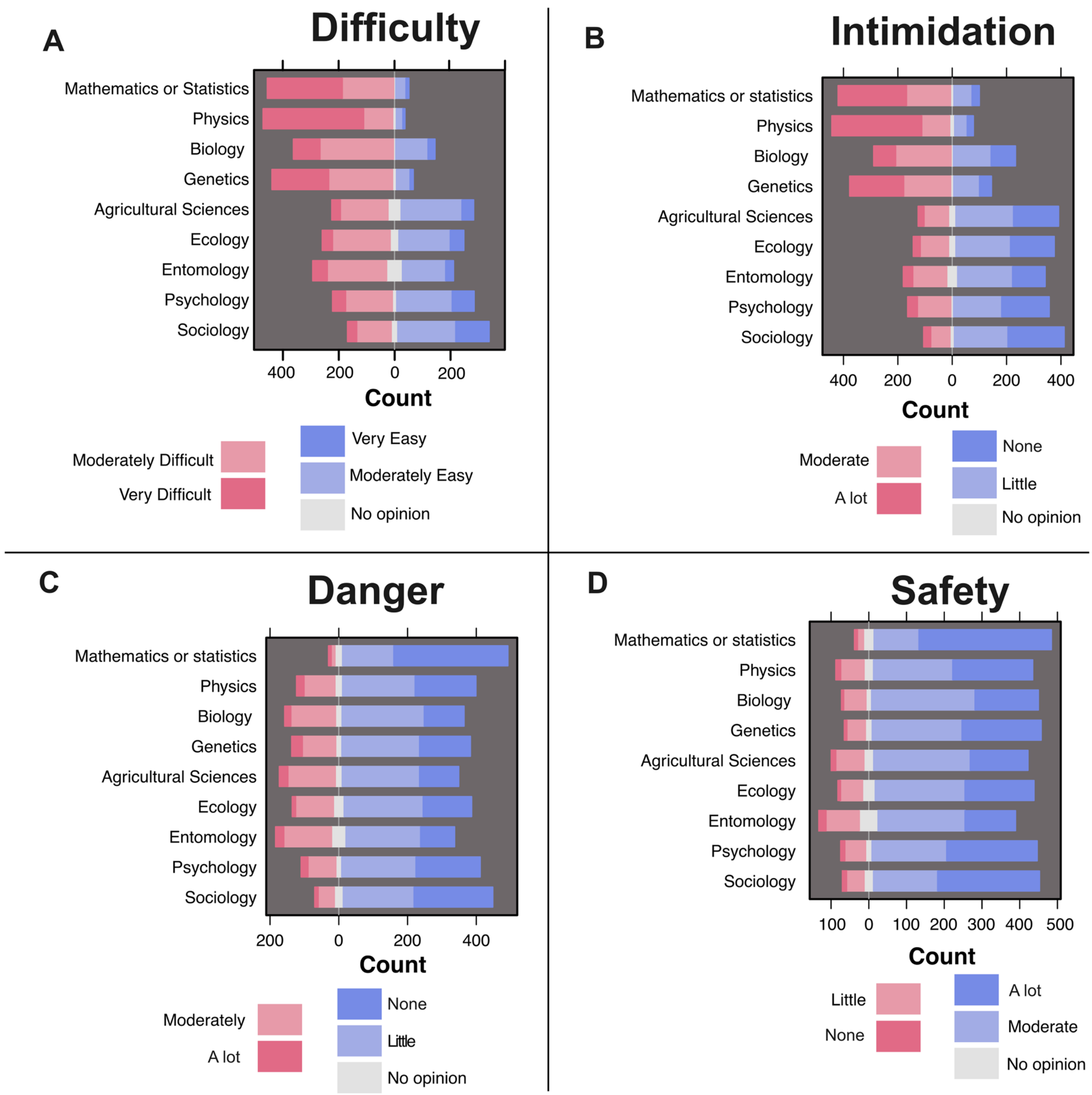

Fig. 3. Perceptions of academic fields in two categories: A, B) approachability and C, D) fear. The horizontal bars show how many respondents gave each level of response for each academic field. See Fig. 2 for other perceptions quantified.

Effect of Racial Issues on Perceptions

Respondents' perception of academic fields was only influenced by racial issues in two cases (Table 6). First, Black (1.67) and South-East Asian respondents (1.41) reported a stronger influence from racial issues on their perception of biology, with white respondents (1.00) reporting the least effect ($P = 0.0008$). Lastly, in answering the prompt "to what degree is your opinion…motivated by history of race-related exploitation (slavery, racial experimentation, cultural theft, genocide, etc)" Black (1.29) and South-East Asian respondents (1.5) reported a stronger influence on their opinion of ecology, while Latinx respondents (0.58) reported the least effect of racial issues on their opinion of wcology ($P = 0.0002$). There were no significant differences by race with respect to the other individual questions of race-related issues.

We repeated the above analysis after lumping together all non-white respondents as a POC category. In that analysis, there was no correlation between perception of academic fields and POC/non-POC status.

Other Results

There were no differences among racial demographics in terms of their families' perception of agriculture. There was a difference among racial demographics in their families' perception of nature and natural spaces (Table 6). Black, East Asian, and South-East Asian respondents reported their families had more negative perceptions of nature than white respondents. There was also a difference among racial demographics in respondents' own perception of nature and natural spaces (Table 6). Black respondents (0.89), East Asian respondents (0.65), and South-East Asian

Table 3. ANOVA results for comparison of perceptions of academic fields by individual race demographics[a]

Perception category	Test with significant difference	*F* ratio	*P* value	Group means						
				Total	Black	East Asian	Latinx	South Asian	South East Asian	White
Fear	Genetics	5.04	0.0002	0.87	1.26	0.99	0.93	1.07	1.09	0.78
Fear	Biology	4.49	0.0005	0.98	1.29	1.03	1.15	1.33	1.51	0.89
Importance	Agricultural Science	5.32	<0.0001	0.51	0.41	0.74	0.60	0.73	0.76	0.43

[a]Not all perception categories or tests are listed. Only tests with significant differences are shown.

Table 4. ANOVA results for comparison of perceptions of academic fields by pooled race demographics[a]

Perception category	Test with significant difference	*F* ratio	*P* value	Group means		
				Total	POC	White
Fear	Biology	17.74	<0.0001	0.98	1.13	0.89
Fear	Genetics	16.28	<0.0001	0.87	1.02	0.78
Fear	Entomology	14.01	0.0002	1.06	1.22	0.98
Importance	Agricultural Science	14.20	0.0002	0.50	0.62	0.43

[a]Not all perception categories or tests are listed. Only tests with significant differences are shown.

Table 5. ANOVA results for comparison of perceptions of academic fields by gender of respondent[a]

Perception category	Test with significant difference	*F* ratio	*P* value	Group means			
				Total	Female	Male	Gender nonconforming or nonbinary
Total	Biology	8.07	0.0004	0.84	0.73	1.04	0.90
Total	Genetics	7.90	0.0004	1.00	0.89	1.17	1.12
Total	Psychology	25.28	<0.0001	1.06	0.87	1.39	1.24
Total	Sociology	17.55	<0.0001	1.24	1.08	1.55	1.32
Total	Physics	20.36	<0.0001	1.49	1.63	1.13	1.84
Total	Math/Stats	19.10	<0.0001	1.11	1.26	0.78	1.28
Total interest	Genetics	7.22	0.0008	1.01	0.90	1.18	1.16
Total interest	Psychology	24.85	<0.0001	1.11	0.91	1.45	1.36
Total interest	Sociology	15.59	<0.0001	1.32	1.15	1.62	1.44
Total interest	Physics	20.47	<0.0001	1.52	1.68	1.13	1.88
Total interest	Math/Stats	19.09	<0.0001	1.18	1.35	0.82	1.33
Fear	Agricultural Science	14.20	<0.0001	1.02	1.08	0.81	1.39
Importance	Genetics	7.91	0.0004	0.49	0.42	0.64	0.52
Importance	Psychology	12.02	<0.0001	0.57	0.48	0.78	0.45
Importance	Sociology	10.63	<0.0001	0.72	0.63	0.94	0.59
Job availability	Psychology	10.34	<0.0001	1.17	1.04	1.31	1.69

[a]Not all perception categories or tests are listed. Only tests with significant differences are shown.

respondents (0.58) reported more negative perceptions of nature than Latinx respondents (0.48).

Discussion

Our study was designed to identify the differences in perception of entomology among demographic groups of undergraduate students and how those compared to perceptions of other fields. The overarching aim was to assess barriers to recruitment or retention of underrepresented populations in entomology and related sciences. The results identified that entomology is perceived much differently than other STEM fields, but the differences among demographics were narrow or nonexistent. In general, racial groups and sexual orientations showed very few differences in perceptions, while gender groups showed many (Christensen et al. 2014). We also found much greater disparities among demographics for STEM fields other than entomology (eg psychology, sociology, physics, math).

Comparison of Academic Fields and Demographics: Among Discipline Differences and Drivers of Diversity Gaps

Although entomology was very negatively perceived overall (Figs 2 and 3), entomology was also viewed as welcoming,

Table 6. ANOVA results for comparison of the effect of racial issues on academic fields, and additional tests about socioeconomic drivers of racial diversity gaps by race of respondent[a]

Perception category	Test with significant difference	*F* ratio	*P* value	Group means						
				Total	Black	East Asian	Latinx	South Asian	South East Asian	White
Race issues (overall)	Biology	4.25	0.0008	1.09	1.67	1.07	1.08	1.15	1.41	1
Race issue 3	Ecology	5.07	0.00015	0.81	1.29	0.85	0.58	0.83	1.5	0.74
Family perspective on nature	Yes	4.94	0.0007	0.4	0.89	0.66	0.48	NA[b]	0.58	0.3
Self-perspective on nature	Yes	4.9	0.0007	0.28	0.59	0.54	0.16	NA	0.45	0.22

[a]Racial demographics not shown were also omitted due to low sample size.
[b]"NA" indicates a lack of sufficient sample size for that group.

nonintimidating, and less difficult than fields such as physics or genetics. While there is some contradictory evidence in the literature (Lips 1992), Rosenzweig and Chen (2023) demonstrated that perceived high difficulty of a discipline could dissuade students from certain fields. Unfortunately, the perceived low difficulty of entomology does not seem to be counteracting its overall negative perception. While there are racial and socioeconomic correlates to how students make decisions based on their perceived chance of success in a field (Quadlin 2021, Bravo and Stephens 2023) this did not seem to translate to racial disparities in the perception of the difficulty of entomology. Still, low perceived difficulty can be beneficial because it is less alienating than the alternative (Dost 2024). Finally, entomology was not viewed significantly differently by races in most perception categories, including the three race-related issues. In some preliminary analyses, when there was actually a racial disparity in how entomology was viewed (eg race issue 1) entomology was viewed more favorably by POC respondents.

Although the negative perception of entomology did not differ much by demographic (Table 4–6), we hypothesize one scenario where this could still be a driver of the diversity gap in entomology. Students will choose STEM fields based on which they see as most desirable to least desirable. Underrepresented students, like all other students, may therefore be recruited into disciplines that are generally more desirable or popular. Unpopular fields may not have access to diverse populations since underrepresented students are, by definition, low in number. If true, this effect would be particularly stark because the starting population (undergraduates) is already not-diverse. Amplifying the effect even further, if popular STEM fields are also trying to diversify, and are therefore making progressive recruitment decisions, unpopular STEM fields will be left with a low diversity recruitment pool.

We see no evidence that the history of agricultural slavery in North America negatively impacts students' perception of entomology or agricultural science. Black and white respondents both rated agricultural science with less fear than other demographics (Table 3). This could also be related to the history of public land-grant black colleges and universities supporting agricultural science historically. Various Asian-identifying respondents generally rated agricultural science more negatively (Table 3), indicating a potential relationship to immigrant status or cultural differences, although this assumes that Asian respondents are more likely to come from immigrant families than white and Black respondents. There were some significant differences in the effect of racial issues on perceptions of STEM majors, but none of them directly relate to entomology or agricultural science (Table 6). There were no racial differences when asking respondents about their families' perspectives on agriculture. Since prior research suggests that family support is key for students' career decisions (Whitehead 2018, Watkins and Mensah 2022, Bravo and Stephens 2023), we see no evidence that this is driving the diversity gap in agricultural sciences. Literature suggests that Black Americans were more negative toward agriculture than white Americans (Hunte 1992, Kaufman et al. 1998) but much time has passed since these findings. Our research could indicate a cultural shift, differences in survey populations, or simply could be due to the specific wording of our questions.

Perspectives on nature were significantly different among groups (Table 6). Prior research also points out differences between Black and white populations in their interest with nature (Kaufman et al. 1998, Taylor 2019, DeVille et al. 2021; but note that racial disparities on opinions of environmental issues is much more nuanced; Lazri and Konisky 2019). It is not clear exactly which academic fields this would affect though. We have no data on how recruitment to the STEM disciplines we included is tied to perspectives on nature. Since our question specifically referred to "natural spaces," we imagined that this would be most evocative of ecology, but ecology is relevant to urban environments too. Sharik and Frisk (2011) found that the environment a student grew up in was strongly predictive of their interest in majoring in forestry. Specifically, students most interested in a degree in forestry were more likely to have spent significant time in nature, or rural settings, particularly in their adolescence. We show that the trend identified by Sharik and Frisk (2011) may have an unexplored racial correlation and that future study should expand this investigation for entomology, ecology, agricultural science, and other STEM disciplines.

Despite numerous differences by gender for other disciplines, our survey found no differences in the perception of entomology across gender categories (Table 6). Zahry and Besley (2017) also did not find a relationship between gender and interest in the major "agriculture and natural resources." However, one of the strongest trends we observed when comparing respondents with differing sexualities was across cis-hetero identifying and LGBTQIA+ respondents. LGBQ respondents were much more likely to rate entomology as beautiful ($F = 5.88$, $P = 0.006$) but less approachable (ie low on hospitality or higher in difficulty; Table 6). While it is difficult to determine what may drive the beauty result, we have some hypotheses. For one, the metaphor of metamorphosis (as seen among Holometabolous insects) has been used for several queer campaigns (eg Hands In, Hands On; LGBTQIA Resource Center 2024). Another hypothesis is that LGBTQIA+ populations may have more representation of people who appreciate nontraditional beauty, or appreciation of beauty that is otherwise socially unacceptable.

We saw by far the strongest effect sizes among respondents compared across genders. In this regard, physics and psychology were diametric opposites–psychology had the strongest difference between females (positive perception) and nonfemales (more negative), and physics almost equally strong effects between female, nonbinary and gender nonconforming (more negative) and male (more positive) respondents (Table 5). Math and statistics showed roughly the same as physics, but with slightly lower effect sizes. Sociology showed the same as psychology but with slightly lower effect sizes. These trends held for total perception and numerous subcategories. Yet, despite the numerous strong differences in perceptions by gender, there were few differences, if any, among our target disciplines. None of the specific gender identities we examined appears to differ from each other in their overall perception of entomology, ecology, and agricultural science.

Limitations

To prevent overinterpreting the results, we keep the following issues in mind. First, our statistical tests were 2-tailed. For instance, there was a statistically significant difference in how racial demographics perceived the importance of agricultural science. In this test, Black respondents rated it more important than the mean while Asian respondents rated it as less important than the mean. The only meaningful interpretation is that Black and East Asian responses were significantly different from each other, but the differences between other group pairings is unknown. Second, the results are only applicable in the context of the survey. Our respondent pool is only representative of undergraduate students, and they are biased toward students at a few US universities majoring in biology, psychology, and math. Third, any predictions about underlying drivers should consider broad factors. For example, "race-related exploitation" influenced at least two racial demographics' opinions of ecology. Considering that each respondent may have complex and nuanced reasoning behind their answers, and that each demographic group is far from a monolith, we should not automatically accept simplistic explanations. Fourth, the above issues should be considered simultaneously. Finally, some of the factors tested and discussed here (job availability, hospitality/welcoming, beauty) had only a single prompt in our survey, so these results should be interpreted with skepticism.

Conclusions

Our survey results suggest that, as scholars have often stated (eg Watkins and Mensah 2022), there are diversities of opinion among People of Color, and while there was common ground across historically excluded groups with respect to gender, sexuality, and racial diversity, one cannot assume that historically excluded peoples are a monolith. As efforts to diversify the field of entomology proceed, tailored actions must address differences in perceptions of entomology and of agricultural science in general with respect to importance, safety, difficulty, and so on.

Entomology is among the most negatively viewed STEM fields, and it was viewed negatively by almost all demographics equally. Therefore, entomologists should be concerned with improving the overall perception of our field if they want to recruit a strong workforce for the future. Our results show that entomology is thought of as easier than other sciences, and respondents did not report any effect of race-related issues on their perception of entomology. Yet still, entomology ranked as the most negatively perceived of in almost all subcategories. Thus, huge efforts to ameliorate this are needed. This could include presenting counter-stereotypical views of entomologists (eg see Reed and Hoback [2024]'s "draw a scientist" entomologist study), improving public perception of insects (Leandro and Jay-Robert 2019), and advertising the numerous financial benefits of a career in entomology. We saw that Black respondents were least often interested in working with insects (Table 2), had generally low appraisal of entomology's importance (Table 3), but also the most often motivated by improving society or helping other people (Table 2). Thus, entomologists might do better to highlight the ways entomology improves society and helps humans. Our own data and prior research (Quadlin 2021) suggest that this could also diversify recruitment patterns with respect to gender too.

Recommendations for Recruitment and Retention

Entomology and agricultural science:

- Outreach for improving perceptions of entomology, and insects in general, may be hugely important for diversifying entomology.
- Recruitment strategies may attract a more racially diverse pool of applications if they emphasize the importance of entomology to individuals and communities.
- In particular, messaging for entomology recruitment campaigns should focus on how entomologists help humans and improve society. This could maximize impact among Black, LGBTQ, and female students.
- Targeting entomological recruitment in queer communities may have strong yields.
- Further research and more diverse perspectives are needed to understand the negative perceptions of agricultural science among Asian student populations.

Biology and ecology:

- Recruitment strategies could perhaps attract a more racially diverse pool of applications if they downplay ecological subdisciplines related only to natural spaces.
- More research is needed to tease apart the effect of race-related issues on the negative perception of biology and ecology, particularly as it relates to the history of slavery.

Psychology and sociology:

- Strategies for better integrating males into these disciplines could yield strong societal outcomes. Since sociology and psychology are essential fields for creating a healthier, more just society, these goals may be better achieved through more equitable recruiting.

Mathematics, statistics, and physics:

- Strong actions should be taken to counter the alienation of women, nonbinary, gender nonconforming people, and

LGBTQIA+ people. These disciplines are fundamental to all other STEM fields, yet they are strongly negatively perceived by nonmales (also see Lips 1992) and nonheterosexuals.

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Supplementary Material

Supplementary material is available at *Annals of the Entomological Society of America* online.

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Conflicts of Interest

None declared.

Data Availability

The data underlying the results discussed here are not shared publicly in order to protect the privacy of the participants. The authors will respond to requests for data sharing in the given Institutional Review Board agreement. The survey is provided in the Supplementary Material.

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