Functional Ecology

British Ecological Society

Editor and reviewer gender influence the peer review process but not peer review outcomes at an ecology journal

Charles Fox, C. Sean Burns and Jennifer Meyer

Peer review is a standard and essential component of scientific publishing, but is managed by a narrow and non-random segment of the scientific community – senior editors and editorial boards are disproportionately men, well established (i.e., more senior) scientists, and can write fluently in English. This limited diversity might generate disparities in editorial and peer review that contribute to gender and geographic disparities in scholarly publishing. Here we examine a comprehensive dataset of the peer review process for all papers submitted to this journal, Functional Ecology, from January 2004 to June 2014, to examine how gender, seniority and geographic location of editors and reviewers influence reviewer recruitment and scores given to papers by reviewers.

Functional Ecology editors have been and continue to be majority male, but the number of female editors has increased over time until, in 2014, ~40% of editors handling manuscripts for the journal were women. Reviewers selected by editors to review submissions to the journal were also highly majority male, but the proportion of women selected as reviewers increased over time. This increase is largely caused by an increasing number of female editors because they invited more female reviewers than did male editors. Male editors selected <25% female reviewers, but female editors consistently selected ~30-35% female reviewers. –Similarly, editors over-selected reviewers from their own geographic locality. The proportion of women among selected reviewers decreased with editor seniority when the editor was male but increased with editor seniority when the editor was female. Thus early-career male and female editors differed little in the proportion of women invited to review, but late-career (more senior) male and female editors differed a lot in the proportion of women they invited to review.

Women invited to review were less likely to respond to invitation emails, but were more likely to agree to review if they responded. Men that were invited to review were both less likely to respond to the invitation and more likely to decline

Photo credit: Jennifer Meyer

if the editor handling the paper was female. In contrast, women responded to invitations similarly regardless of whether the editor inviting them was male or female. Unexpectedly, individuals invited to review were less likely to agree to review if the editor handling the paper, and thus selecting the reviewers, was more senior.

Despite differences between male and female editors, and between male and female reviewers, on aspects of the peer review process, we observed no differences on outcomes – neither review scores given to papers nor final decisions (the proportion of papers rejected) differed between male and female reviewers or male and female editors.

Editor gender, seniority and geographic location affect who is invited to review for Functional Ecology, and how invitees respond to review invitations, but not the final outcome of the peer review process. We suggest that, to increase diversity of reviewer populations, journals should increase gender, age and geographic diversity of their editorial boards.

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Editor and reviewer gender influence the peer review process but not peer review outcomes at an ecology journal

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Summary

1. Lack of diversity on editorial boards might generate disparities in editorial and peer review that contribute to gender and geographic disparities in scholarly publishing.

2. We use a comprehensive data set of the peer review process for all papers submitted to the journal *Functional Ecology* from January 2004 to June 2014 to examine how gender, seniority and geographic location of editors and reviewers influence reviewer recruitment and scores given to papers by reviewers.

3. The gender ratio of editors for *Functional Ecology* was majority male, but the proportion of female editors increased over time. The gender ratio of selected reviewers was also highly majority male, but the proportion of women selected as reviewers increased over the 10 years largely because the number of women on the editorial board increased and female editors invited more female reviewers than did male editors. Male editors selected $<25\%$ female reviewers even in the year they selected the most women, but female editors consistently selected ~30–35% female reviewers. Editors also over-selected reviewers from their own geographic locality.

4. Women invited to review were less likely to respond to review invitations, but more likely to accept if they responded. Women invited to review responded to the invitation similarly regardless of whether the editor inviting them was male or female, but men invited to review were both less likely to respond and more likely to decline if the editor was female.

5. Review scores given to papers did not differ between male and female reviewers, and final decisions (proportion of papers rejected) did not differ between male and female editors.

6. The proportion of women among selected reviewers *decreased* with editor seniority when the editor was male but increased with editor seniority when the editor was female. Thus, the gender ratio of selected reviewers differed little between early-career male and female editors but differed a lot between late-career (more senior) male and female editors. Individuals invited to review were *less* likely to agree to review if the editor was more senior.

7. Editor gender, seniority and geographic location affect who is invited to review for *Functional Ecology*, and how invitees respond to review invitations, but not the final outcome of the peer review process. To increase diversity of reviewer populations, journals should increase gender, age and geographic diversity of their editorial boards.

Key-words: editorial board composition, gender balance, gender bias, peer review

Introduction

Despite attempts to achieve gender parity in the sciences, men generally occupy a greater proportion of scientific positions (after graduate school) than do women (Shen 2013; Ceci *et al.* 2014). This disparity is especially evident in leadership and other high-profile positions that determine the scientific agenda, such as on editorial boards (Dickersin *et al.* 1998; Grod, Lortie & Budden 2010; Cho *et al.* 2014), in working groups (Campbell *et al.* 2010), at symposia (Schroeder *et al.* 2013) and in invited editorials

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and commentaries (Ochuko-Emore, Beezhold & Morakinyo 2010; Nature 2012; Pettorelli *et al*. 2013). Researchers have identified a wide variety of factors that contribute to gender disparity in the sciences and in scientific publishing (Larivière *et al*. 2013; Ceci *et al*. 2014). These include a mix of social, educational and workplace factors that lead to two general outcomes: deterrence from entering science fields or greater attrition out of science fields. Instructional differences in elementary and secondary education (Greenfield 1997), gender stereotypes regarding innate talent (Leslie *et al*. 2015) and lack of female academic advisors and role models (Fox 2008; Griffith 2010) can deter women from entering scientific careers. Different preferences for teaching vs. data analysis (Lockwood, Reiners & Reiners 2013), subconscious biases favouring male over female applicants in job searches (Moss-Racusin *et al*. 2012), workplace conditions or family factors (Holt & Webb 2007; Ledin *et al*. 2007; Ceci & Williams 2011; Adamo 2013; Shen 2013), and differential treatment by professional colleagues and administrators (Monroe *et al*. 2008) or by grant and journal reviewers, programme officers and/or editors (Rees 2011) can motivate women to pursue alternative careers (Adamo 2013).

Scholarly publication – how many and where papers are published, and citations to those papers – is a common proxy of an individual's research contributions and is a major factor in determining success when scientists compete for research grants (Kaltman *et al*. 2014) or apply for promotion or tenure (Park & Gordon 1996). Authorship therefore functions as a signal of gender inequality in the sciences and acts as a potential contributor to it. For example, women tend to publish less often than men on a per capita basis (Symonds *et al*. 2006; Ledin *et al*. 2007) and globally account for <30% of authorships (accounting for the number of authors; Larivière *et al*. 2013). Women also tend to be under-represented as first and last authors and over-represented as middle authors relative to their overall frequency as authors, though the degree to which this is the case varies among disciplines (Martin 2012; West *et al*. 2013). These results may indicate that women tend to have different roles in scientific research projects, or they may reflect biases in the processes underlying how authorship is determined (which also varies among disciplines), that can affect subsequent perception of female vs. male authors' roles in a research project.

Biases in scientific gatekeeping, particularly during editorial and peer review, may contribute to gender disparity, perceived or real, in scholarly publishing (Bornmann 2011; Siler, Lee & Bero 2015). For example, calls for double-blind peer review to replace the more commonplace single-blind peer review system (e.g. Budden *et al*. 2008) have been motivated by a perception that papers authored by female scientists are reviewed less positively than papers authored by male scientists (but see Ceci & Williams 2011; Lee *et al*. 2012). However, biases may extend beyond author gender. Notably, editorial boards – the decision-making bodies of most scientific journals – tend to be composed of proportionately more men than in the scholarly communities they serve (Morton & Sonnad 2007; Amrein *et al*. 2011; Mauleón *et al*. 2013; Cho *et al*. 2014; http://timotheepoisot.fr/2014/11/24/editorial-boards-gender-bias/), and this disparity is often greater at more senior editorial levels (McSweeney, Donahoe & Swindell 2000; Addis & Villa 2003; Porter, Christian & Poling 2003; but see Mauleón *et al*. 2013). Although the number of women on editorial boards has been increasing, the rate of increase is generally slower than the rate of increase in female authorship observed in those same journals (Jagsi *et al*. 2008).

Lack of female representation on editorial boards can have diverse effects. Appointment to an editorial board can increase the visibility and prestige of a scientist, influencing employment and promotion for scientists who are invited to participate. Gender disparities in editorial board selection can also influence journal management; for example, female editors tend to view open access policies more favourably than do male editors (Alzahrani 2010). Editorial board composition likely also affects reviewer selection (Buckley *et al*. 2014), which in turn might influence peer review outcomes. In one survey of ecology journal editors, male editors considered reviewer *status* more important than did female editors (Grod, Lortie & Budden 2010), possibly reflecting different experiences with male-dominated science or different professional networks (Lloyd 1990; Grod *et al*. 2008). In particular, differences in social and professional networks between male and female scientists (McPherson, Smith-Lovin & Cook 2001) may lead female editors to choose reviewers of different academic rank and/or gender from those chosen by male editors, which could in turn affect review scores and the probability a paper is published. Yet, despite well-documented gender disparities in editorial board composition, there is little data on whether these disparities impact the peer review process (Wing *et al*. 2010).

In addition to gender disparity issues, editorial boards of scholarly journals that publish for international communities can be geographically unrepresentative of their author communities (Willett 2013; but see Uzun 2004; García-Carpintero, Granadino & Plaza 2010). Geographic representation of scientists on editorial boards of international journals may better reflect the distribution of PhD-granting institutions for a subject than the professional locations of the authors published by these journals (Hodgson & Rothman 1999) or reflect the ownership of the journal. In particular, US academics dominate the editorial boards of leading journals in a number of fields (García-Carpintero, Granadino & Plaza 2010; Willett 2013), likely because there is a higher volume of scholarly research output and PhD production from the United States than from other nations (Braun & Dióspatonyi 2006; Zhou & Leydesdorff 2006; Leydesdorff & Wagner 2009). As most international journals are published in English (Belcher 2007), they must necessarily recruit editors who have fluency in writing English.

Regardless of the reason why editorial boards are often geographically biased, such non-representative editorial boards may lead to geographic disparities throughout the entire peer review process. This may lead to a reduction in the diversity of perspectives and approaches valued by the editorial board and represented in a journal (Hodgson & Rothman 1999).

In this paper, we examined a comprehensive data set of the peer review process for all papers submitted to the *Functional Ecology* from January 2004 to June 2014 to examine (i) how editor gender influences gender balance in reviewer recruitment, (ii) how reviewer gender influences responses to review invitations and review scores given to papers, and (iii) whether editor seniority and geographic locality mediate the effects of editor and reviewer gender on the peer review process.

Materials and methods

DATA SET

Functional Ecology uses *ScholarOne Manuscripts* (previously *Manuscript Central*) to manage manuscript submissions and peer review. We extracted data from *ScholarOne* on 19 December 2014 for all 'standard' papers submitted to *Functional Ecology* between 1 January 2004 and 30 June 2014 (inclusive). 'Standard' papers include all typical research studies (empirical or theoretical), but exclude review papers, commentaries, perspectives, editorials and other types of papers not considered typical research manuscripts. We only examined the reviews of papers during their initial submission to the journal. Papers sent for re-review following revision are not included in our analysis. We chose 30 June 2014 as our cut-off to ensure that all papers examined had completed the editorial process. Over this time period (January 2004–June 2014), the journal received 6720 submissions of standard papers. Of these standard papers, 3865 papers were sent out for peer review.

Throughout our analysis, we distinguish three reviewer categories determined by the manuscript handling processes of the journal. The handling editor for each manuscript compiles a list of suggested reviewers (henceforth called *selected reviewers*) which they submit electronically to the editorial office, with reviewers generally ranked in order of preference. The editorial office then invites reviewers for the manuscript (henceforth *invited reviewers*), usually in the order listed but with consideration of the selected reviewer's recent workload for the journal; those currently reviewing other papers or who have reviewed multiple papers recently are not invited unless necessary. *Invited reviewers* are thus a subset of *selected reviewers* reflecting, but not identical to, the editor's ranking of selected reviewers. Reviewers who accept the invitation to review are henceforth called *agreed reviewers*. Only ~5% of agreed reviewers fail to return a review, though many return their reviews later than in the requested 3 weeks.

Our data set includes a total of 23 516 reviewers *selected* by editors, covering 8533 unique individuals. Of these reviewer selections, 17 958 invitations to review were sent to 7551 unique individuals, 8763 of these invitations led to an agreement to review (from 4898 unique individuals), and 8288 reviews were submitted to *Functional Ecology*.

VARIABLES IN THE DATA SET

Our data set contains the complete list of all reviewers selected and invited by editors in our time frame. We also have data on whether the reviewer responded to our invitation (see caveat below), how long the invitee took to respond, their specific response (whether to review or not), how long they took to submit their review (from when they accepted) and the score submitted for the paper (Table 1). These data are available for the entire period of the study, except for two variables. The length of time to respond to our invitation email was not consistently recorded until the beginning of 2007. Also, although reviewer responses to invitation emails have been recorded for the entire length of the study, 'no response' outcomes (i.e. the reviewer did not reply to our invitation email) are recorded manually by the editorial office. Unfortunately, 'no response' outcomes were not recorded for most papers in 2006, and 'no response' was only recorded haphazardly pre-2006. We thus only include 'no response' outcomes in our analysis of reviewer response rates for papers submitted starting on 1 January 2007.

ASSIGNING GENDER

We assigned gender to all reviewers in our data base using a mixture of personal knowledge and Internet searches. If a reviewer was not personally known to one of the editors, we entered their name into an online data base of given names (genderize.io) that includes >200 000 unique names. If a name returned a probability of being male or female that was 0·99 or less, we did an Internet search (using google.com) to find the reviewer. We searched for individual web pages or entries in online data bases (such as profiles on Google Scholar, Mendeley.com, ResearchGate.com, Twitter or Facebook) that included a photograph of the individual. In a few cases, we found news stories interviewing scientists that referred to 'he' or 'she' or other pronouns that indicate gender. Because our reviewers are generally chosen from established scientists, we found the overwhelming majority in our web searches. A small proportion of reviewers were identified only by their first initial and their last name, but these could mostly be linked to specific individuals because our data base includes reviewer institution (for most entries), email address and the title of the paper they reviewed (indicating their general area of expertise). We were able to assign a gender to all but 161 unique reviewer entries. An additional 78 unique reviewers had given names that are primarily (>97%) male or female in genderize.io. We were thus able to

Table 1. Reviewer score categories used by *Functional Ecology*

2004 to September 2006
1 = Accept for publication with only editorial changes
2 = Accept after minor changes not requiring further referee assessment
3 = Reject in present form, but encourage resubmission of new manuscript
4 = Reject without prospect of resubmission
September 2006 to December 2011
1 = Accept following minor revision
2 = Requires major revision
3 = Reject, topic not of enough importance or general interest for *Functional Ecology*
4 = Reject, quality of data set/manuscript not adequate for *Functional Ecology*
January 2012 to June 2014
1 = An extremely novel paper that is in the top 10% of all papers you have read in the broader field of ecology
2 = A strong contribution to the broader field of ecology
3 = Solid work, but largely confirmatory
4 = Weak or flawed, or not of enough importance and general interest for *Functional Ecology*

assign gender to 23 414 entries in our data set, which is all but 102 of the entries (83 unique reviewers) in our data set.

EDITOR SENIORITY

We identified the year that most *Functional Ecology*'s editors obtained their PhD from either the editors' CVs or websites, by the *ProQuest's Dissertations & Theses* data base (ProQuest.com), or by contacting editors personally. We were unable to obtain the exact year of PhD graduation for four past editors (including one who is deceased), so we estimated their PhD graduation year from the address changes on their published manuscripts (the year they switched from using their graduate school address to postdoctoral address on published manuscripts). We then calculated *Editor Seniority* as the year of interest (e.g. at appointment to the editorial board or at the time of manuscript submission) minus the PhD graduation year. Because degrees are awarded at various times of year and we only know the year (not month) of graduation, our estimates of academic seniority should be considered plus-or-minus ~2 years of the actual time between the date of interest and the actual PhD graduation of the editor. We also consider the number of years that an editor has served on this specific journal's editorial board at the time they handled a particular manuscript.

REVIEWER GEOGRAPHIC LOCATION

Our data set includes the home country of most reviewers we invited. These entries are reviewer- or editor-submitted and reflect the most recent location of the reviewer according to their last data base entry. Some scientists move between countries/continents during their careers, and such changes may not be reflected in our data base. Nonetheless, we expect most reviewer location data to be correct, with the errors creating random noise in the data.

We used the United Nations' M.49 area codes and their continental regions defined by the United Nations' Statistical Commission (unstats.un.org) to categorize reviewer localities. However, there were two exceptions: (i) we split the Americas into Latin America (which includes North America south of the United States–Mexico border) and North America (the United States and Canada) and (ii) we split Europe into the United Kingdom and 'other Europe'. This latter change is to reflect that *Functional Ecology* is owned by a British society [the *British Ecological Society* (BES)] and the editorial board includes a substantial representation of editors from the United Kingdom (much greater representation of editors from the United Kingdom than expected from the distribution of ecologists in Europe).

STATISTICAL ANALYSES

Most of the variables we examined in this study have binary responses: reviewer replies to an invitation email (yes/no), agrees to review (yes/no) and gender of the reviewer (f/m). For analyses in which these are our dependent variables, we used logistic regression with models of the form: *DependentVariable = Year + IndependentVariables + Interactions*. *Year* is a categorical variable that represents when the paper was submitted. Analyses of handling editor gender include handling editor identity as a random effect nested within handling editor gender. Logistic regression analyses were performed using SAS PROC LOGISTIC or SAS PROC GLIMMIX (SAS Institute, Cary, NC, USA) (when including handling editor identity as a random effect). Least-squares means (LSMeans) were calculated for some response variables to remove among-year variation; these means were calculated using SAS PROC GLIMMIX (dist = binomial, using the ILINK switch to calculate means as proportions rather than odds ratios).

We used general linear models to analyse time data (time to respond to invitation, time from acceptance to submission of review) and reviewer scores (using SAS PROC GLM). Time to respond to the review invitation and time from acceptance to submission of review were log-transformed before analysis to meet the assumptions of analysis of variance. The influence of editor geographic origin on the geographic distribution of reviewers selected by editors was analysed using a χ^2 test.

Results

REVIEWER AND EDITOR GENDER

The proportion of all selected, invited and agreed reviewers that were women increased over the 10 years since 2004 (Fig. 1a). The proportion of women among all names submitted by editors (selected reviewers in Fig. 1) was lowest in 2004 (17·6%) but increased gradually to a high of

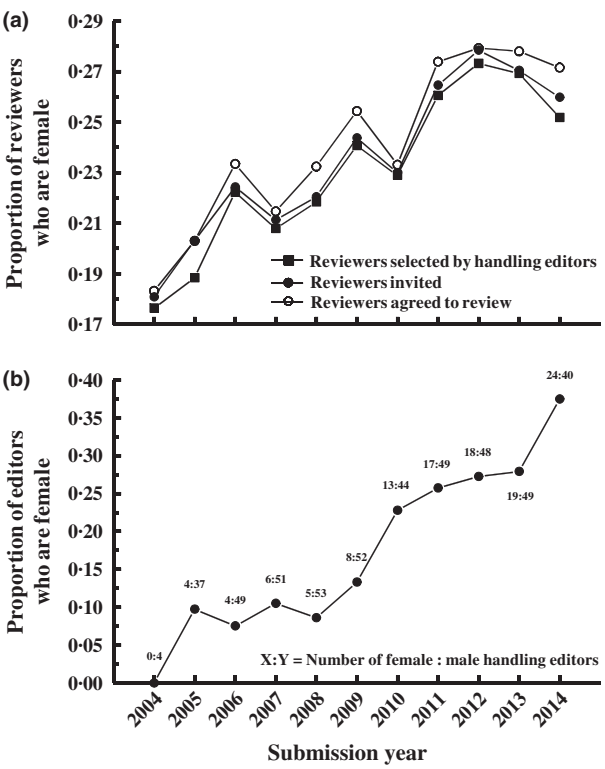

Fig. 1. The gender ratio (proportion women) of (a) reviewers for papers submitted to *Functional Ecology* and (b) handling editors. Each reviewer entry in the data set (for panel a) is treated as a single data point. See Fig. S1 for an analogous figure for unique reviewers. 'Reviewers selected' are the reviewers chosen by handling editors. 'Reviewers invited' are the reviewers invited by the editorial office and are a subset of all reviewers selected by editors. 'Reviewers agreed' are the subset of invited reviewers who agreed to review for the journal. The composition of the journal editorial board varies throughout each year as editors join or leave the board; the counts in panel (b) include the number of unique editors who handled at least one paper that was submitted during the particular calendar year. The journal had only four handling editors in 2004, and all were male. The number of female handling editors increased gradually since then, from 4 (out of 41 total handling editors) in 2005 to 24 (out of 64 total handling editors) in 2014.

27·3% in 2012, after which it appears to have plateaued (26·9% in 2013 and 25·2% in the first half of 2014; logistic regression; *ReviewerGender*[m/f] = *Year*; $\chi^2_{10} = 112{\cdot}4$, $P < 0{\cdot}001$). Likewise, the proportion of women among all agreed reviewers was lowest in 2004 (18·3%) and increased until 2012 when it reached 27·9%, and stayed ~27% for the following 2 years (27·8 and 27·2 in 2013 and 2014, respectively; *Year*: $\chi^2_{10} = 44{\cdot}9$, $P < 0{\cdot}001$). These results mirrored the pattern for the proportion of unique reviewers that were women (see Fig. S1, Supporting information).

In 2004, all manuscripts submitted to *Functional Ecology* were handled by one of four male editors. In 2005, the journal began recruiting a board of Associate Editors to handle manuscripts, with consideration given to having both geographic and gender diversity. The subsequent increase in gender diversity on the editorial board (Fig. 1b) appears to be largely responsible for the increase in the frequency of female reviewers. This is because female editors include a higher proportion of women among their selected reviewers than do male editors (Fig. 2; *ReviewerGender* [m/f] = *Year* + *EditorGender* + *Interaction*; *Year*: $\chi^2_{10} = 20{\cdot}6$, $P = 0{\cdot}02$; *EditorGender*: $\chi^2_1 = 9{\cdot}55$, $P = 0{\cdot}002$; *Interaction*: $\chi^2_9 = 6{\cdot}96$, $P = 0{\cdot}64$). This difference between male and female editors in the gender ratio of the reviewers they selected translated into a significant difference in the gender ratio of agreed reviewers. Notably, though the frequency of women reviewers invited by male editors has increased since 2004 (open circles in Fig. 2; $\chi^2_{10} = 59{\cdot}3$, $P < 0{\cdot}001$), this increase has been small and it appears that most of the increase in the frequency of women reviewers is caused by the increase in the proportion of *Functional Ecology* editors that are women.

The proportion of women among reviewers that agreed to review is slightly higher than the proportion invited to review (Fig. 1a). This is because women who received invitations to review were ~6% more likely to agree to review than were men, if they responded to the invitation (Fig. 3a) (logistic regression; *Agreed*[yes/no] = *Year* + *Reviewer Gender*; *Year*: $\chi^2_{10} = 481{\cdot}2$, $P < 0{\cdot}001$; *ReviewerGender*: $\chi^2_1 = 9{\cdot}7$, $P < 0{\cdot}002$). However, women were less likely to respond to review invitations (Fig. 3b) (*Respond*

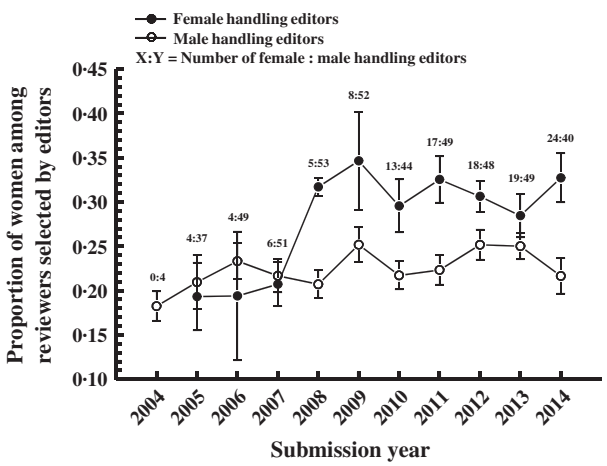

Fig. 2. The proportion of selected reviewers who are female for papers handled by female editors (●) vs. male editors (○). 'Selected reviewers' are the reviewers requested by the handling editor and are a larger set of people than those actually invited by the editorial office. The numbers (X/Y) above each point are the numbers of women (X) and men (Y) who handled at least one paper that was submitted during that particular year. The means are calculated by first calculating the proportion of female reviewers separately for each editor and then by averaging across editors within each gender.

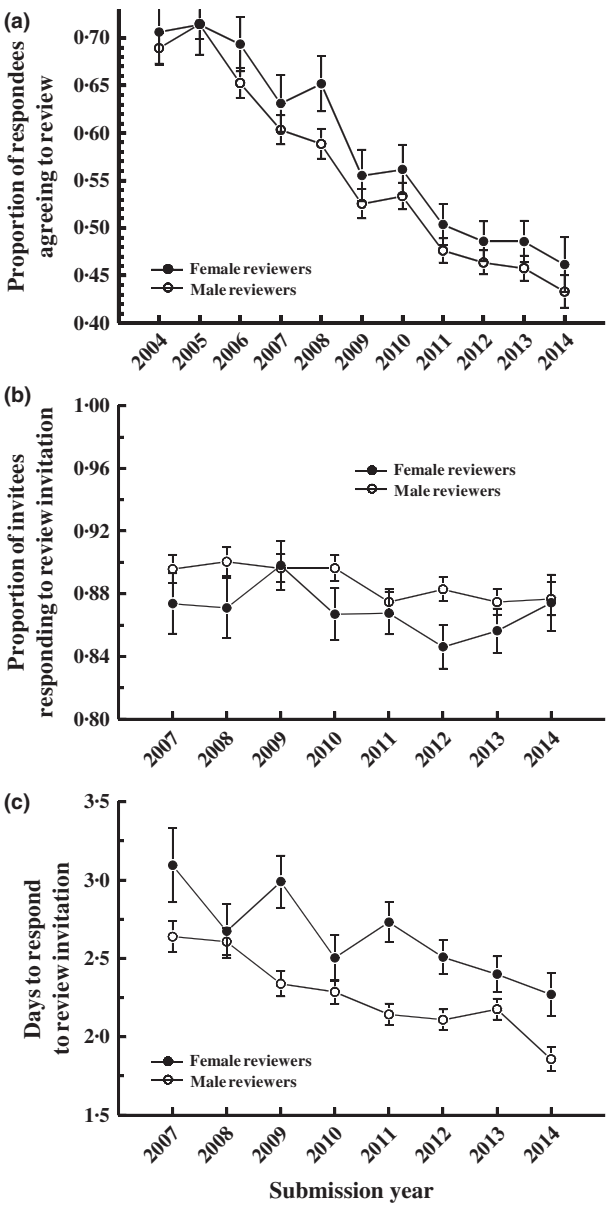

Fig. 3. (a) The proportion of respondents (those responding to an emailed invitation to review) who agreed to review for the journal for female (●) vs. male (○) reviewers. (b) The proportion of invitees responding to the review invitation. (c) The time between when the journal sent the invitation to review and the prospective reviewer responded to the invitation (positively or negatively).

[yes/no] = *Year* + *ReviewerGender*; *Year*: $\chi^2_7 = 13{\cdot}6$, $P = 0{\cdot}06$; *ReviewerGender*: $\chi^2_1 = 9{\cdot}2$, $P < 0{\cdot}003$) and were slower to respond to these invitations (Fig. 3c; *Year*: $F_{7,12826} = 9{\cdot}9$, $P < 0{\cdot}001$; *ReviewerGender*: $F_{1,12826} = 53{\cdot}1$, $P < 0{\cdot}001$). These two effects largely counteracted each other such that the probability that an invitee responded and agreed to a review invitation was at most slightly (~2%) higher for female than male reviewers ($\chi^2_1 = 3{\cdot}70$, $P = 0{\cdot}054$).

When reviewers are invited to review for *Functional Ecology,* they are told the name of the handling editor. We were interested in whether the gender of the handling editor, which is generally obvious from the editor's name, might influence the reviewer's likelihood to review. Overall, invitations from female editors were slightly less likely to be accepted than were invitations from male editors, but there was a significant interaction between the gender of the editor and gender of the reviewer (*Agreed*[yes/no] = *Year* + *ReviewerGender* + *EditorGender* + *ReviewerGender*EditorGender Interaction*; *Year*: $\chi^2_{10} = 389{\cdot}4$, $P < 0{\cdot}001$, *ReviewerGender*: $\chi^2_1 = 14{\cdot}9$, $P < 0{\cdot}001$, *EditorGender*: $\chi^2_1 = 2{\cdot}62$, $P = 0{\cdot}047$, *Interaction*: $\chi^2_1 = 8{\cdot}76$, $P = 0{\cdot}003$). Due to the interaction, we tested for the effects of editor gender on reviewer responses separately for male and female reviewers. There was no significant effect of editor gender on whether women responded to the review invitation (Fig. 4a; *Respond* = *Year* + *EditorGender*; *EditorGender* effect: $\chi^2_1 = 0{\cdot}27$, $P = 0{\cdot}61$) or agreed to review if they respond (Fig. 4c; $\chi^2_1 = 0{\cdot}08$, $P = 0{\cdot}77$). In contrast, men were less likely to respond to the invitation (Fig. 4b; $\chi^2_1 = 5{\cdot}46$, $P = 0{\cdot}02$) and less likely to agree to review (Fig. 4d; $\chi^2_1 = 9{\cdot}39$, $P = 0{\cdot}002$) when the editor was female.

We found no editor gender effect on how quickly either men or women responded to review requests (*EditorGender* effect in full model: $F_{1,1944} = 0{\cdot}41$, $P = 0{\cdot}52$) and no evidence that reviewers who agreed to review responded more quickly (or slowly) to the invitation to review compared to reviewers who declined to review ($P > 0{\cdot}23$ for both male and female reviewers). The time between

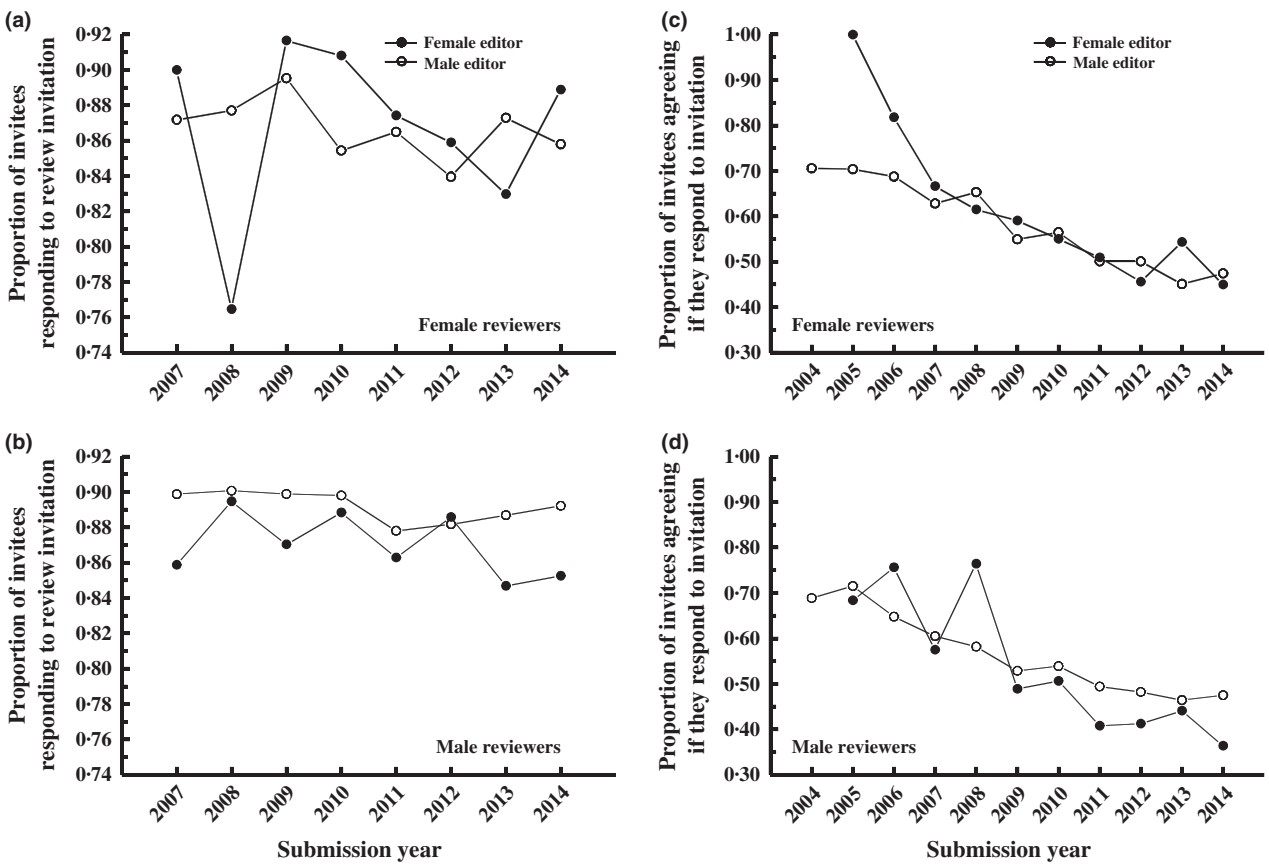

Fig. 4. (a, b) The proportion of invited reviewers who responded to the review invitation (agreed or declined vs. no response), and (c, d) the proportion of respondents who agreed to review, for when the editor is female (●) vs. male (○). The top panels (a, c) are for female reviewers, and the bottom panels (b, d) are for male reviewers. The data demonstrate that female reviewers (panels a and c) respond to requests and agree to review equally whether the editor is male or female. In contrast, male reviewers (panels b and c) are less likely to respond and less likely to agree to review if the editor is female. These gender differences are especially notable since 2009; prior to 2009, the data are quite noisy because the journal had few female editors, and thus, few papers were handled by female editors (the number of male and female editors per year is presented in Fig. 1b). Data for response rates (panels a and c) are presented only for 2007–2014 because 'no response' was not consistently recorded before 2007.

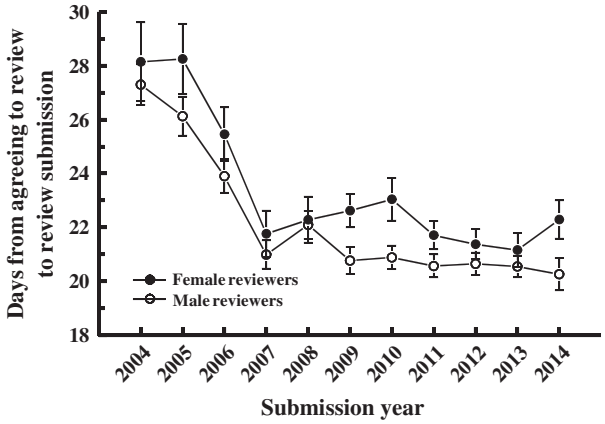

Fig. 5. The number of days between accepting a review invitation and submitting a review for female (●) vs. male reviewers (○). There is substantial variation among years, and a difference between male and female reviewers, but no detectable effects of editor gender, and no editor-x-reviewer gender interactions. Model: SquareRoot (*DaysToReview*) = *Year* + *ReviewerGender* + *EditorGender* + All Interactions; *Year*: $F_{10,8214} = 5{\cdot}15$, $P < 0{\cdot}001$; *ReviewerGender*: $F_{1,8214} = 14{\cdot}0$, $P < 0{\cdot}001$; *EditorGender*: $F_{1,8214} = 2{\cdot}72$, $P = 0{\cdot}10$; All interactions: $P > 0{\cdot}37$.

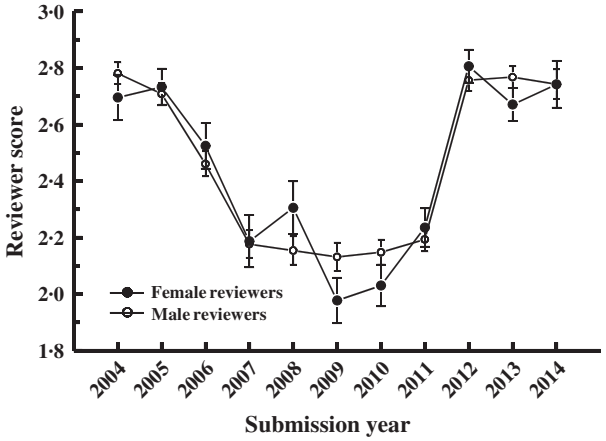

Fig. 6. The average score given to manuscripts by female (●) vs. male (○) reviewers. Note that a *lower* review score is a better score (higher ranking). Mean reviewer scores have changed substantially over time, but there were no detectable effects of reviewer or editor gender, and no significant interactions. Model: *ReviewerScore* = *Year* + *ReviewerGender* + *EditorGender* + All Interactions; Year: $F_{10,8157} = 32{\cdot}0$, $P < 0{\cdot}001$; *ReviewerGender*: $F_{1,8157} = 0{\cdot}12$, $P = 0{\cdot}73$; *EditorGender*: $F_{1,8157} = 0{\cdot}28$, $P = 0{\cdot}60$; All interactions: $P > 0{\cdot}05$. Note that the large fluctuation in scores across years reflects changes in the scoring categories, with a decline in average scores accompanying the switch from one scoring system to another in late 2006, and a rise in average scores in 2012 accompanying another change in the scoring categories at the start of 2012 (see Table 1 for details).

accepting a request and submitting a review declined substantially between 2004 and 2007, but then stabilized at an average of ~21–22 days (Fig. 5). Men submitted their reviews on average 1·3 days (5%) more quickly than did women (Fig. 5; statistical analysis in the figure legend); however, there was no effect of the handling editor's gender on the time it took either men or women to submit their review and no interaction between reviewer and editor gender.

Though reviewer scoring of papers has varied substantially over time (likely reflecting changes in the proportion of papers sent out for peer review, the scoring categories used by the journal and the instructions given to reviewers), there was no evidence that average scores differed between male and female reviewers (Fig. 6) or between male and female editors. There was no evidence that review score was related to how quickly reviewers responded to the original invitation or how quickly they submitted their review after agreeing (when included in the full model presented in Fig. 6; Log[*DaysToRespond*]: $F_{1,6437} = 0{\cdot}25$, $P = 0{\cdot}61$; SQRT[*DaysToReview*]: $F_{1,6437} = 1{\cdot}38$, $P = 0{\cdot}24$).

We found no evidence that female editors were more or less likely than male editors to reject a paper without sending it for review (i.e. editorial reject; model: *Reject*[yes/no] = *Year* + *HandlingEditorGender* + *Interactions*; *HandlingEditorGender*: $\chi^2_1 = 0{\cdot}09$, $P = 0{\cdot}77$; this analysis excludes rejections made by the senior editors before assignment to a handling editor). Of the papers sent for review, *AverageReviewerScore* was an excellent predictor of whether the paper was rejected or not, and we found no evidence that female editors were more or less likely to reject a paper after review (model: *Reject*[yes/no] = *Year* + *HandlingEditorGender* + *AverageReviewer Score* + *Interactions*; *HandlingEditorGender*: $\chi^2_1 = 0{\cdot}12$, $P = 0{\cdot}73$; *AverageReviewerScore*: $\chi^2_1 = 521{\cdot}0$, $P < 0{\cdot}001$; *Year*AverageReviewerScore*: $\chi^2_9 = 16{\cdot}6$, $P = 0{\cdot}055$).

EDITOR SENIORITY AND EXPERIENCE ON THE EDITORIAL BOARD

There was no detectable difference in academic seniority (years since PhD) of male and female editors at the time of their appointment to the *Functional Ecology* editorial board (mean ± SEM; men: 14·6 ± 0·8 years; women: 13·0 ± 1·3 years). There was also no evidence that academic seniority at the time of editorial appointment varied across years for either male or female editors (*Editor Seniority* = *Year* + *EditorGender* + *Interaction*; *Year*: $F_{13,101} = 1{\cdot}13$, $P = 0{\cdot}35$, *Gender*: $F_{1,101} = 0{\cdot}10$, $P = 0{\cdot}88$; *Interaction*: $F_{8,101} = 0{\cdot}77$, $P = 0{\cdot}63$).

We detected a highly significant editor gender-x-seniority interaction for the gender of reviewers selected ($\chi^2_1 = 14{\cdot}7$, $P < 0{\cdot}001$); that is, the proportion of women among selected reviewers *declined* with editor seniority, albeit only slightly, when the editor was male (slope is significantly <0; $\chi^2_1 = 6{\cdot}55$, $P = 0{\cdot}01$) but *increased* with editor seniority when the editor was female (slope is significantly greater than 0; $\chi^2_1 = 9{\cdot}8$, $P = 0{\cdot}002$; Fig. 7a) (the interaction between year and seniority was non-significant, $P > 0{\cdot}07$, for both male and female editors). As a consequence, the gender ratio of selected reviewers differed markedly between late-career (more senior) male and female editors, but differed very little between early-career

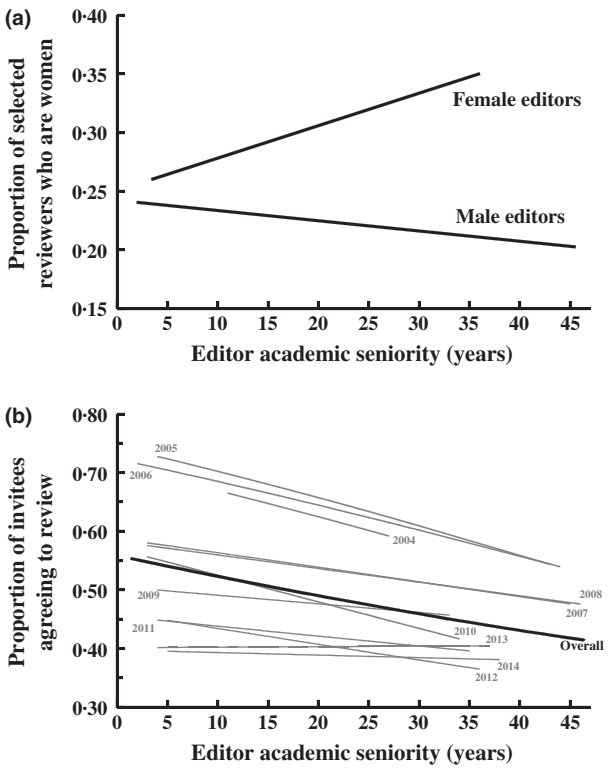

Fig. 7. The relationship (predicted values from a logistic regression) between editor academic seniority (years since PhD at time of handling a manuscript) and (a) the proportion of selected reviewers who are women, and (b) the proportion of invitees who agreed to review. Additional details: (a) The predicted values from the logistic regression *ReviewerGender*[m/f] = *Year* + *EditorSeniority*, calculated separately for each sex (females: *Year*, $\chi^2_9 = 17{\cdot}8$, $P = 0{\cdot}04$, *EditorSeniority*, $\chi^2_1 = 9{\cdot}8$, $P = 0{\cdot}002$; males: *Year*, $\chi^2_{10} = 61{\cdot}7$, $P < 0{\cdot}001$, *EditorSeniority*, $\chi^2_1 = 6{\cdot}5$, $P = 0{\cdot}01$; Year-x-Seniority interactions were non-significant and so not included in the model when calculating predicted values). Results are presented by individual years in Fig. S2. (b) The grey lines are the predicted values from a logistic regression with each slope representing one year of submissions. The black line is the overall best-fit slope removing the among-year variation. The full analysis: *Year*: $\chi^2_{10} = 366{\cdot}4$, $P < 0{\cdot}001$; *ReviewerGender*:$\chi^2_1 = 11{\cdot}8$, $P < 0{\cdot}001$; *HandlingEditorGender*:$\chi^2_1 = 3{\cdot}6$, $P = 0{\cdot}06$; *ReviewerGender-x-EditorGender*:$\chi^2_1 = 9{\cdot}9$, $P = 0{\cdot}002$; *EditorSeniority*:$\chi^2_1 = 27{\cdot}8$, $P < 0{\cdot}001$; *EditorYearsOnBoard*:$\chi^2_1 = 1{\cdot}8$, $P = 0{\cdot}18$.

(less senior) male and female editors. In contrast to this effect of editor seniority on the gender ratio of selected reviewers, the number of years an editor had been on the editorial board at the time they were assigned a paper did not influence the gender ratio of reviewers they selected and did not account for the editor gender effect reported above and in Fig. 2 (*ReviewerGender* [m/f] = *Year* + *EditorGender* + *EditorYearsOnBoard*; *Year*: $\chi^2_{10} = 43{\cdot}5$, $P < 0{\cdot}001$; *EditorGender*: $\chi^2_1 = 71{\cdot}2$, $P < 0{\cdot}001$; *EditorYearsOnBoard*: $\chi^2_1 = 2{\cdot}6$, $P = 0{\cdot}11$).

The academic seniority of the handling editor, but not the number of years they had served on the editorial board, was predictive of whether invited reviewers responded to the review invitation (*EditorSeniority*: $\chi^2_1 = 14{\cdot}0$, $P < 0{\cdot}001$; *EditorYearsOnBoard*: $\chi^2_1 = 1{\cdot}03$, $P = 0{\cdot}31$) and whether they agreed to review a paper if they responded to the invitation (*EditorSeniority*: $\chi^2_1 = 19{\cdot}5$, $P < 0{\cdot}001$; *EditorYearsOnBoard*: $\chi^2_1 = 2{\cdot}14$, $P = 0{\cdot}14$). Reviewers were *less* likely to respond, and *less* likely to agree to review, if the editor was a more senior academic (the full model was *Respond*[yes/no] or Agree [yes/no] = *Year* + *EditorGender* + ReviewerGender + *EditorAcademicSeniority* + *EditorYearsOnBoard* + *TwoWayInteractions*). Thus, overall, invitations to review were *less* likely to recruit a reviewer if the handling editor was more senior, independent of the number of years of service on the editorial board (Fig. 7b).

The editor seniority effect did not differ between male and female reviewers (*EditorSeniority-x-ReviewerGender* interaction; $\chi^2_1 = 0{\cdot}32$, $P = 0{\cdot}57$) or male and female editors (*EditorSeniority-x-HandlingEditorGender* interaction; $\chi^2_1 = 0{\cdot}03$, $P = 0{\cdot}85$). Importantly, considering an editor's academic seniority and years of service on the editorial board was *not* adequate to explain the differences between male and female invitees in the effect of editor gender on invitation responses (the effects shown in Fig. 4b,d); the probability that an invitee responded to a review invitation, and the probability that respondents agreed to review, continued to depend on handling editor gender when the invitee was male ($P < 0{\cdot}002$ for both variables) but not when the invitee was female ($P > 0{\cdot}54$ for both variables) after accounting for an editor's academic seniority and years of service on the editorial board.

We found no evidence that academic seniority of the editor, or the number of years they had served on the board at the time they were assigned a manuscript, affected how likely they were to reject a paper without sending it for peer review (*EditorSeniority*: $\chi^2_1 = 0{\cdot}93$ $P = 0{\cdot}16$; *EditorYearsOnBoard*: $\chi^2_1 = 0{\cdot}56$, $P = 0{\cdot}46$) or after peer review (*EditorSeniority*: $\chi^2_1 = 1{\cdot}62$ $P = 0{\cdot}20$; *EditorYearsOnBoard*: $\chi^2_1 = 2{\cdot}69$, $P = 0{\cdot}95$).

EDITOR AND REVIEWER GEOGRAPHIC LOCATION

Overall, editors selected more reviewers from North America (the United States and Canada) than from any other geographic region (Table 2). Notably, the geographic distribution of reviewers selected depended on the locality of the handling editor (Table 2; $\chi^2_{36} = 1665{\cdot}6$, $P < 0{\cdot}001$); editors from most regions over-selected reviewers from their own geographic region relative to the overall frequency of reviewer selection from that same region. For example, editors from Australia and New Zealand selected reviewers from these two countries more often (18·4% of their selected reviewers) than did other editors (≤8·1%). Likewise, editors from the United Kingdom (UK) selected reviewers from the UK more often (18·4%) than did other editors (≤15·6%), and editors from Europe (excluding the UK) selected reviewers from Europe more often (42·3%) than did other editors (≤27·0%).

Table 2. The geographic distribution of reviewers chosen by editors from different geographic localities. For example, 55·4% of reviewers selected by North American editors were from North America, whereas only 7·3% of reviewers chosen by North American editors were from Australia or New Zealand. Columns sum vertically to 100%. Note that editors tend to select reviewers from their own geographic region (shaded cells) more frequently than reviewers from that geographic region are selected by editors from other regions

	Editor Region (%)						
	North America[1]	United Kingdom	Other Europe[2]	Australia and New Zealand	Africa[3]	Asia	Latin America[4]
Reviewer Region							
North America	55·4	40·1	36·2	47·0	43·4	47·6	58·3
United Kingdom	10·3	18·4	9·3	8·8	15·6	8·1	6·3
Other Europe	22·5	27·0	42·3	20·5	24·7	21·1	14·2
Australia and New Zealand	7·3	8·1	6·9	18·4	6·0	8·6	6·3
Africa (primarily South Africa)	0·7	1·0	0·9	0·9	4·9	0·7	2·4
Asia	1·6	2·6	2·3	2·9	2·2	10·2	0·0
Latin America	2·1	3·0	2·1	1·6	3·4	3·7	12·6

[1]The United States and Canada.
[2]Europe excluding the United Kingdom.
[3]Entirely South Africa.
[4]Includes South America, Central America, plus Mexico and the Caribbean countries.

The gender ratio of reviewers selected by editors varied with reviewer geographic locations (logistic regression; model: *ReviewerGender*[f/m] = *Year* + *ReviewerRegion* + *Interaction*; *Year*: $\chi^2_{10} = 26{\cdot}1$, $P = 0{\cdot}004$; *ReviewerRegion*: $\chi^2_6 = 72{\cdot}6$, $P < 0{\cdot}001$; *Interaction*: $\chi^2_{60} = 72{\cdot}9$, $P = 0{\cdot}12$); it was most male-biased for South African and Asian reviewers (proportion female = 0·07 and 0·15, respectively) and least male-biased for Latin American and North American reviewers (proportion female = 0·29 and 0·25, respectively) (gender ratios are least-squares means correcting for among-year variation, calculated using SAS PROC GLIMMIX, dist = binomial).

We found no evidence that reviewers from different geographic localities varied in the frequency of failing to respond to review requests (respond vs. 'no response'; data not presented). However, the frequency with which reviewers agreed to review (probability of acceptance if invited) varied among reviewer geographic localities, with reviewers from North America and South Africa least likely to agree to review (Fig. S3A; analyses in the figure legend). Although women were more likely to agree to review (as discussed above), we found no evidence of any interaction between reviewer gender and either reviewer or editor location, or between editor gender and reviewer or editor location ($P > 0{\cdot}24$ for all). We did find a significant interaction between reviewer locality and handling editor locality for the probability that a reviewer agreed to review, but it was *not* generally the case that reviewers accepted reviewer invitations with higher frequency if the editor was from the same geographic region (Table S1).

Reviewer scores varied slightly, but significantly, among geographic regions (Fig. S3B); reviewers from North America, Latin America and the United Kingdom tended to rate papers lower than did reviewers from other areas.

Discussion

Editors and reviewers play a critical role as gatekeepers for contributions to the scientific literature. As such, disparities in editorial board composition and reviewer selection can influence the success of scientists in disseminating their research, which in turn can affect scientific careers. In this study, we examined the gender and geographic composition of the editorial and reviewer populations for the journal *Functional Ecology* and how gender and geography influence the peer review process and outcomes for papers submitted to the journal. Our key results are as follows:

1. The proportion of women selected to be reviewers depended on the editor's gender. This difference in reviewer selection between male and female editors was particularly large for more senior editors.
2. Women invited to review were less likely to respond to the invitation email and took longer to respond to the invitation, but were more likely to agree if they responded.
3. Women invited to review responded to the invitation similarly regardless of whether the editor inviting them was male or female, but men invited to review were both less likely to respond and more likely to decline if the editor was female.
4. Review scores given to papers did not differ, on average across all papers, between male and female reviewers, and decisions made by editors (both pre- and post-review) did not differ between male and female editors.
5. Reviewers were *less* likely to agree to review when invited by a more senior editor.
6. Editors selected more reviewers from their own geographic communities (compared to overall averages).

EDITOR GENDER, SENIORITY AND GEOGRAPHY AFFECT REVIEWER RECRUITMENT

The gender ratio of scientists invited to review papers for *Functional Ecology* became less male-biased over the 10·5 years of our study, but remains substantially male-biased, reaching no better than ~28% women in the least gender-biased year (Fig. 1). Most of the change in gender ratio of reviewers appears to be driven by an increase in the number of female editors recruited to handle papers for the journal. This is because women editors, especially more senior women editors, invite substantially more female reviewers than do male editors (Figs 2 and 7a). The proportion of women among scientists selected to review by male editors also became less male-biased over time, but male editors continue to select substantially fewer women reviewers than do female editors. We also found that editors generally over-select reviewers from their own geographic region (relative to editors from other regions). Thus, a major conclusion of our study is that to increase diversity among journal reviewer populations, journals need to increase gender and geographic diversity of their editorial boards. Though our data are for only one journal, our editorial and reviewer populations overlap substantially with those of other journals in this field (ecology) and so should be generalizable at least across the field of ecology if not more broadly across scholarly publications.

Serving as an editor or being invited to review, especially for a journal that is well regarded in a scientist's field, carries a prestige pay-off that can influence hiring and promotion decisions. If the gender composition of editorial boards affects the gender distribution of peer review invitations, as our data indicate (see also Petty, Fleming & Fabrigar 1999; Buckley *et al*. 2014), or affects other kinds of editor invitations (e.g. if female editors invite more women to write editorials or review papers; McSweeney, Donahoe & Swindell 2000), then disparities in editorial board appointments can negatively affect female scientists' access to these prestige pay-offs both directly (reduced participation in editorial boards) and indirectly (reduced frequency as reviewers or participation in writing editorials or review paper). An analogous result to our observation that female editors tend to invite more female reviewers is that female editors-in-chief tend to recruit more women to editorial boards (Metz & Harzing 2009; Mauleón *et al*. 2013; but see Amrein *et al*. 2011). There have only been two editors-in-chief (Executive Editors) for *Functional Ecology* since the journal switched to an associate editor model, and both have been male, so we cannot test for this specific gender effect with our data.

We need to be cautious when speculating on whether male editors are under-inviting female reviewers, female editors are over-inviting female reviewers, or both. This is because the gender composition of the scientific community has changed a lot over the last few decades (e.g. Ceci *et al*. 2014) and thus differs depending on whether we consider, for example, all scientists or primarily senior scientists. It is thus unclear what the expected gender distribution should be among reviewers. However, we must still consider why male and female editors differ in their usage of male and female reviewers, and why this difference varies quite substantially with editor academic seniority (our proxy for age). We suspect that there are several contributing factors. First, social and professional networks tend to be structured, at least partially, according to age and gender (McPherson, Smith-Lovin & Cook 2001). This gender structuring in professional relationships is observed in authorship data – women tend to have a higher proportion of junior authorships on papers with female first authors relative to papers with male first authors, and men tend to have a higher proportion of junior authorships on papers with male first authors than on papers with female first authors (Bonnet, Shine & Lourdais 2004). Age structure could also generate gender differences if editor social networks are formed in less vs. more male-biased environments, as might be expected for younger vs. older editors. For *Functional Ecology*, male and female editors do not differ in academic seniority (years since PhD). However, we found that the relationship between editor gender and the gender ratio of selected reviewers differed substantially between male and female editors, with more senior male editors inviting fewer female reviewers than do less senior male editors, and with more senior female editors inviting more female reviewers than do less senior female editors. This difference could reflect historical influences: for example, older scientists were reared and educated in a more gender-structured environment than are younger scientists. Regardless of the mechanism generating social network structure, if editors preferentially choose reviewers from people they have a professional or social relationship with, and those social networks are non-random with respect to gender, we would expect a gender difference in reviewer selection like the one we observed. Alternatively, the especially large effect of editor seniority on female editor recruitment of women reviewers could reflect an effort by more senior women scientists to involve women in the publication process, possibly in a conscious effort to counteract real or perceived male bias in science.

Other factors could contribute to differences in the selection of male vs. female reviewers by male and female editors. Non-random association of editor and reviewer genders could be a result of variation in gender ratio among subject areas of ecology. The gender ratio of researchers varies not just among the major STEM fields (Leslie *et al*. 2015) but also among subdisciplines within fields (e.g. West *et al*. 2013; see especially the gender project at eigenfactor.org). Editors are chosen to handle papers within the subject area and using the study taxa with which they have expertise. This subtle structuring of the ecological community can thus generate covariation between editor and reviewer gender even if reviewers are chosen based only on their expertise and irrespective of gender. Alternatively, male and female editors may weigh

different reviewer criteria differently; for example, male editors may consider status more important (Grod, Lortie & Budden 2010) and select older scientists who may represent a more male-biased community of prospective reviewers. Lastly, editors may exhibit conscious or unconscious biases in which they favour reviewers of their own gender. The first two of these hypotheses can probably be tested with peer review data sets that include age, social/professional network and more detailed subject area data on editors and reviewers, but the third hypothesis – that editors exhibit conscious or subconscious biases against reviewers of the opposite gender – will likely require experimental studies to test. These same processes may also contribute to explaining the preference by editors for reviewers from their same geographic region.

REVIEWER GENDER AFFECTS ASPECTS OF THE PEER REVIEW PROCESS

We found consistent but small differences between men and women in their responses to review invitations. Women were less likely to respond to review invitations (Fig. 3b) and took longer to respond to invitations (Fig. 3c). However, they were more likely to agree to review if they responded (Fig. 3a), but took slightly longer to submit their reviews (Fig. 5). That women responded to review invitations and submitted their reviews more slowly is consistent with some other studies (e.g. Wing *et al*. 2010; but see Davo, Vives & Álvarez-Dardet 2003) and with the large body of data indicating that female scientists, especially those who have families, have greater demands on their time than do male scientists in equivalent social situations (Ledin *et al*. 2007). Alternatively, female reviewers may spend more time reviewing each particular manuscript (Grod *et al*. 2008) and possibly write longer and/or more thoughtful reviews (Wing *et al*. 2010; but see Gilbert *et al*. 1994). That women were less likely to respond to review invitations does not necessarily indicate that women are more likely to ignore emailed invitations. Female scientists leave science at a higher frequency than do men (Fox 2008) and tend to relocate more often than men to satisfy their partners' careers (Ledin *et al*. 2007), such that their email addresses may change and become incorrect in our data base more frequently.

Although we observed small but consistent differences in the time it took women and men to submit reviews, there was no difference in the scores given to papers (Fig. 6). We also found no evidence that female editors were more or less likely to reject a paper, either before or after review, than were male editors. Thus, though the choice of specific reviewers and specific handling editors almost certainly influences how a paper is reviewed and the decision that it receives, we have no evidence that decisions made on papers submitted to *Functional Ecology* are influenced by editor or reviewer gender *per se*. The literature is mixed on whether men or women generally are harsher in their reviews and decisions. A few studies have suggested that female reviewers are more likely to recommend rejection (Borsuk *et al*. 2009; Wing *et al*. 2010) or that female editors are more likely to reject papers (Gilbert *et al*. 1994), and at least one study has found an interaction between reviewer and author gender, with female reviewers reviewing female-authored papers more favourably (Lloyd 1990). However, this interaction was not observed in other studies (Petty, Fleming & Fabrigar 1999; Walker *et al*. 2015) and most analyses of journal peer review data find no effect of reviewer or editor gender on review scores or manuscript decisions (Kliewer *et al*. 2005; Bornmann & Daniel 2007; Grod *et al*. 2008; Isenberg, Sanchez & Zafran 2009; Demarest, Freeman & Sugimoto 2014; Walker *et al*. 2015; note: Demarest, Freeman & Sugimoto 2014 conclude that 'female reviewers gave lower reviews than male reviewers' in their study but clearly state in their Results that this result is not statistically significant). Notably, the studies that report gender bias in journal peer review data sets are generally older than the studies reporting no bias, possibly reflecting changing social attitudes towards women in science (Walker *et al*. 2015).

One concerning result we found is that responses to review invitations depended on the gender of the editor. Women invited to review were equally likely to respond and equally likely to agree to review regardless of whether the handling editor was male or female (Fig. 4a,c). However, men invited to review were less likely to respond and less likely to agree to review if they responded if the handling editor was female (Fig. 4b,d). The difference in responses by men to male vs. female editors is small, but was seen in most years, and was especially clear in later years as the number of female editors increased (and thus sampling error decreased). Interestingly, a similar result for male reviewers was observed for the *Journal of the American Medical Association* more than 20 years ago (Gilbert *et al*. 1994). This result potentially reflects a real bias in which a small proportion of male reviewers consciously or subconsciously are less likely to respond to queries that come from women. It is unlikely that the result is a response to editor prestige; this gender difference in response to reviewers remains highly statistically significant even after including editor seniority and editor tenure on the editorial board as covariates.

EDITOR SENIORITY

Intriguingly, we found that reviewers are *less* likely to respond to a review invitation, and *less* likely to agree to review, if the handling editor is more senior (Fig. 7b). This is counter to the prediction that reviewers will be more likely to agree to review for editors that are more established in their careers and thus of higher status or rank. Possibly, professional status is unrelated to seniority among *Functional Ecology*'s editors. However, we think it more likely the case that senior editors invite, on average, more senior reviewers (those from their social networks) and that more senior reviewers are more likely to decline

to review. The most common reason scholars decline to review is lack of time (Tite & Schroter 2007); administrative duties tend to increase as scientists age (Baccini *et al*. 2014), reducing time available for reviewing and likely explaining why senior scientists submit peer reviews that are judged more poorly than those submitted by junior scientists (Evans *et al*. 1993; Black *et al*. 1998). We expect that more senior scientists are also more frequently asked to review and more likely to decline to review. Unfortunately, we do not have seniority data for our invited reviewers and so cannot test the hypotheses. Despite the negative effect of editor seniority on reviewer recruitment, we found no evidence that either more senior editors or editors who have served on the editorial board for a longer period of time were more (or less) likely to reject a paper either before or after peer review.

Conclusions

Editor gender, seniority and geographic location affect the kind of reviewers selected for *Functional Ecology* and, to a lesser extent, how invitees respond to review invitations. In particular, our editors tend to invite reviewers that are like themselves. It follows that, for the publication process to be made more inclusive, it is necessary to increase gender, age and geographic diversity of journal editorial boards. More generally, improved awareness by journal editors and editorial staff of potential gender and geographic disparities in the reviewer selection process, coupled with self-evaluation of each specific journal's internal processes for reviewer selection, is likely necessary to achieve greater equality in reviewer usage. For example, when choosing reviewers it may be better for editors to rely more on manuscript reference lists and data base searches than on their personal knowledge of individuals working in the field as the latter is heavily influenced by social and professional interactions, which are structured by gender, age, geography and shared experiences. A less easily solved problem is our finding that male prospective reviewers respond less often and less positively to invitations from female editors, a small but consistent effect. One solution might be to blind the names of the editors who are handling a manuscript in invitations sent to reviewers, but this reduces the prestige pay-off that associate editors might receive in attaching their names to their editorial work. It is also possible that reviewers are more likely to agree to review if invited by an identified rather than anonymous editor, a benefit that journals would generally not want to lose. Our study does, fortunately, find some very encouraging results; though reviewer scores varied depending on the geographic locality of the *reviewer* (an observation worth further exploration), we found no evidence that gender of the editor or reviewer affected the review score or final editorial decisions on papers. Further study is necessary to determine whether and how editor and reviewer gender and geography interact with author gender and geography to influence the peer review process and outcome.

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Data accessibility

Data for this project are deposited in the Dryad Digital Repository (doi:10.5061/dryad.5090r). However, because the data set contains information on human subjects, the data available at Dryad are anonymized and lacking variables that allow parts of the data set to be de-anonymized. For example, we do not include details about handling editors (e.g. geographic locality and seniority) that, in combination with gender, would allow identification of many of the handling editors. Please see the metadata accompanying the Dryad submission for additional details.

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Supporting Information

Additional Supporting information may be found in the online version of this article:

Fig. S1. The gender ratio of unique reviewers for papers submitted to *Functional Ecology* (proportion women).
Fig. S2. The relationship between editor academic seniority (years since PhD at time of handling a manuscript) and the proportion of selected reviewers who are women for (A) female editors and (B) male editors.
Fig. S3. Variation among reviewer geographic localities is (A) the proportion (± SEM) of selected reviewers who agree to review according to reviewer geographic locality (B) reviewer scores (± SEM).
Table S1. Probability of agreeing to review for each combination of editor geographic location and reviewer geographic location.

Supplementary Material

Editor and reviewer gender influence the peer review process but not peer review outcomes at an ecology journal

Charles W. Fox, C. Sean Burns and Jennifer A. Meyer

Figure S1. The gender ratio of unique reviewers for papers submitted to *Functional Ecology* (proportion women). Individuals are counted only once in a year regardless of how many times they are invited to review that specific year. “Reviewers selected” are the reviewers chosen by handling editors. “Reviewers invited” are the reviewers invited by the editorial office and are a subset of all reviewers selected by editors. “Reviewers agreed” are the subset of invited reviewers who agreed to review for the journal.

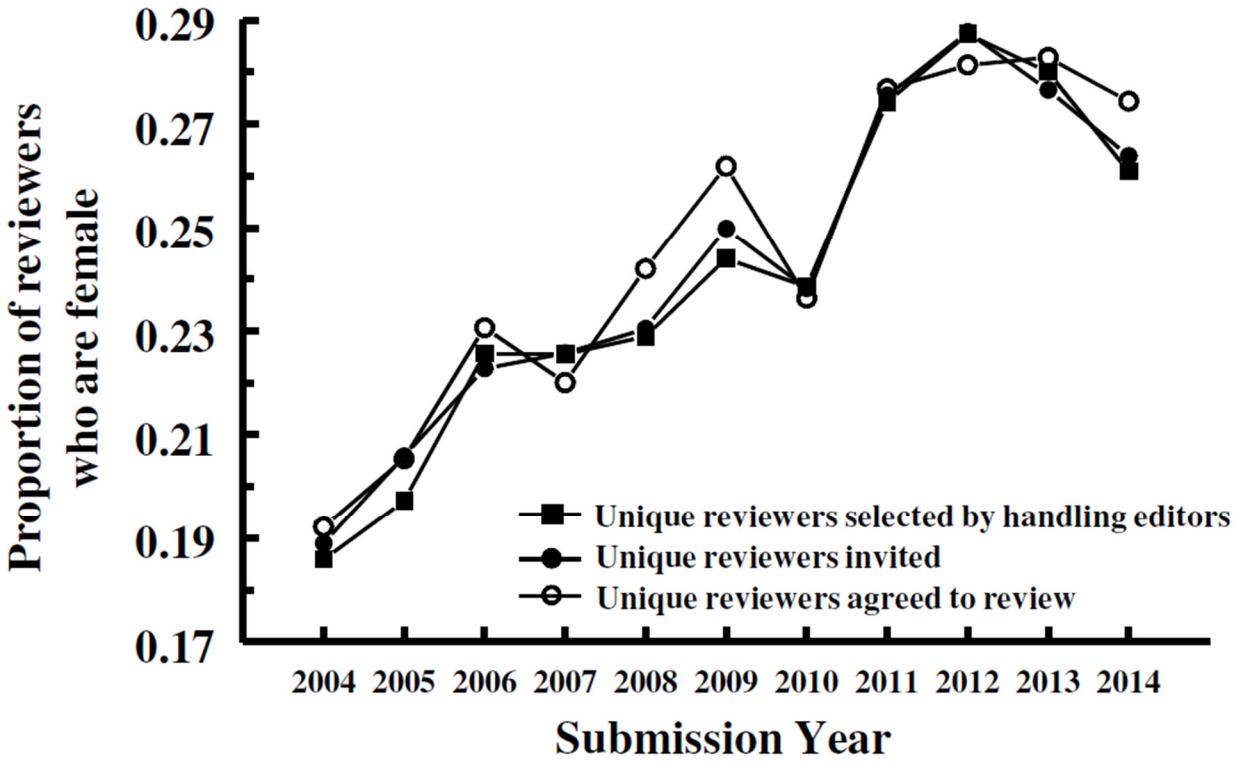

Figure S2. The relationship between editor academic seniority (years since PhD at time of handling a manuscript) and the proportion of selected reviewers who are women for (A) female editors and (B) male editors. Grey lines are individual years and the black lines (also presented in Figure 7A) are the overall best-fit slopes in a logistic regression model including *Year* as a main effect (separate models for each year and gender). The *Year-x-Seniority* interaction was non-significant for both genders of editors. Note that there were no female editors in 2004. The odd nearly vertical slope in A is for 2006 when there were only four female editors who handled few papers; those data contribute very little to the overall slope.

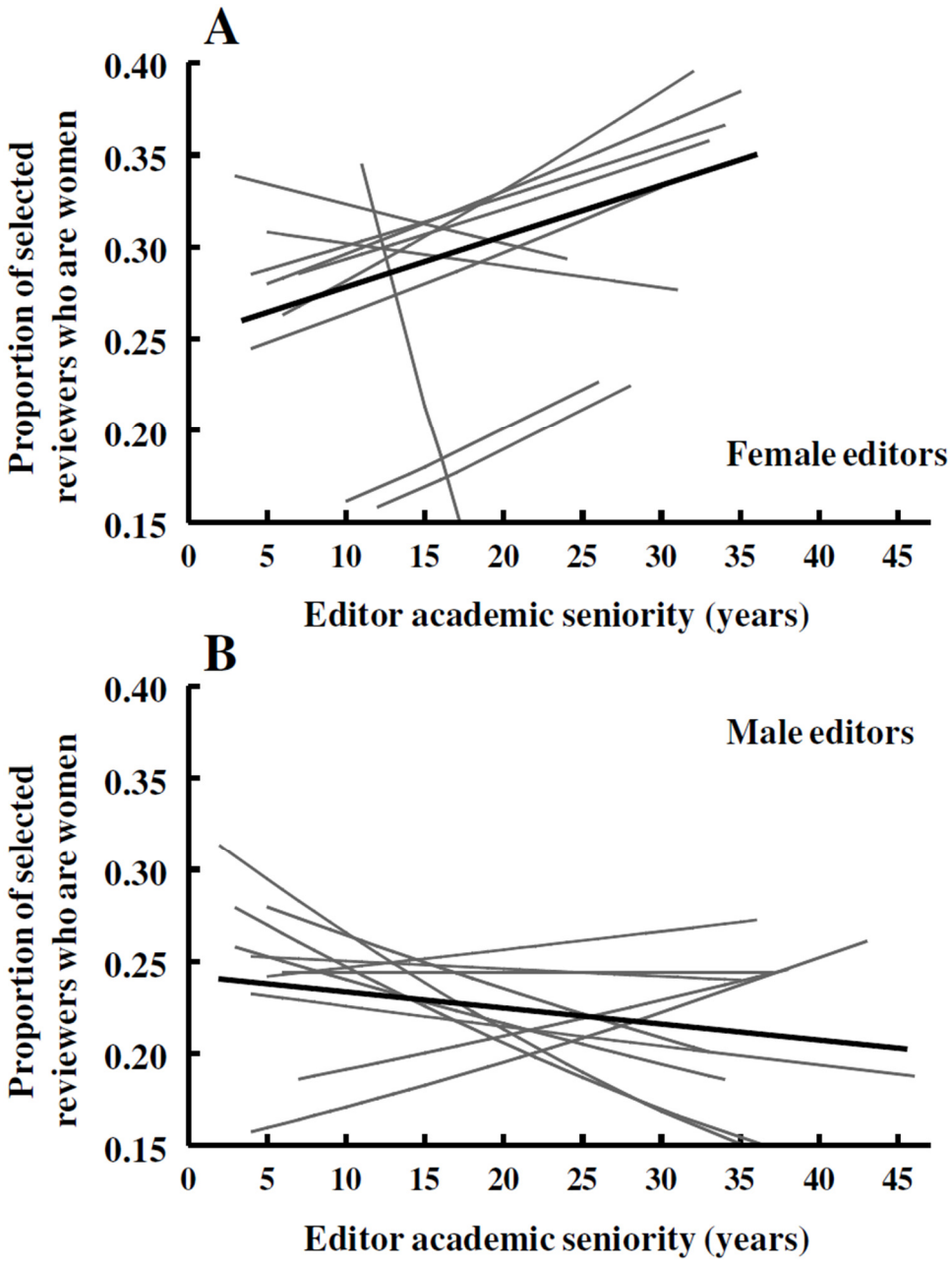

Figure S3. Variation among reviewer geographic localities is (A) the proportion (± SEM) of selected reviewers who agree to review according to reviewer geographic locality (B) reviewer scores (± SEM). Means are Least Squares Means calculated controlling for year and reviewer gender. Proportion agreed (Logistic regression; SAS Proc Glimmix, dist=binomial): *Year*: $X^2_{10} = 535.1$, $P < 0.001$; *ReviewerGender*: $X^2_1 = 7.0$, $P = 0.008$; *EditorRegion*: $X^2_6 = 14.6$, $P = 0.02$; *ReviewerRegion*: $X^2_6 = 16.2$, $P = 0.01$; *Interaction*: $X^2_{10} = 58.2$, $P = 0.008$. *ReviewerScore* (log-transformed; SAS Proc GLM): *Year*: $F_{10,8125} = 60.4$, $P < 0.001$; *ReviewerGender*: $F_{1,8125} = 0.13$, $P < 0.001$, *ReviewerRegion*: $F_{6,8125} = 0.3.68$, $P < 0.002$: †indicates that LSMeans could not be calculated.

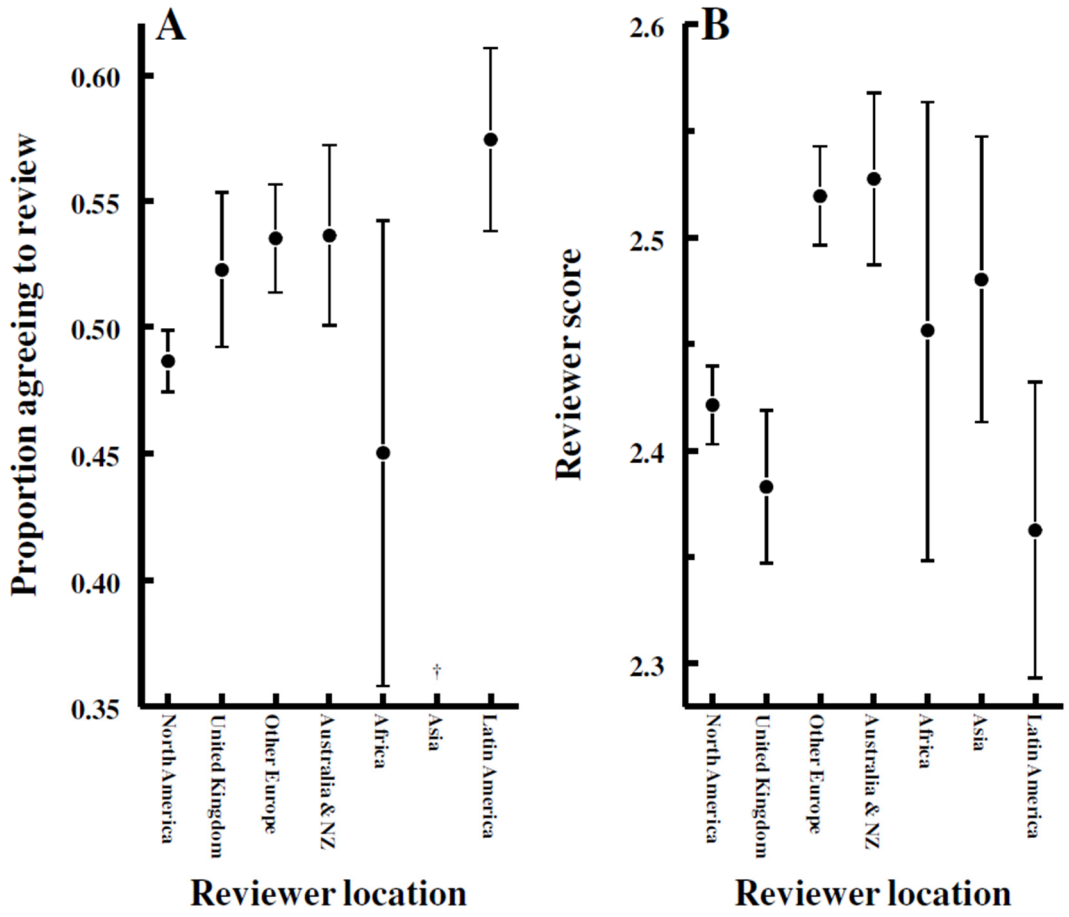

Table S1. Probability of agreeing to review for each combination of editor geographic location and reviewer geographic location. Means are calculated controlling for year and reviewer gender (LSMeans in SAS Proc Glimmix, dist=binomial; Model: *Agreed*[yes/no] = *Year* + *ReviewerGender* + *EditorRegion* + *ReviewerRegion* + *EditorRegion-x-ReviewerRegion*; *Year*: $F_{10,17647} = 53.1$, $P < 0.001$; *ReviewerGender*: $F_{1,17647} = 7.02$, $P = 0.008$; *EditorRegion*: $F_{6,17647} = 1.57$, $P = 0.15$; *ReviewerRegion*: $F_{6,17647} = 3.35$, $P = 0.003$; *Interaction*: $F_{35,17647} = 1.66$, $P = 0.008$).

	Editor Region						
	North America[1]	United Kingdom	Other Europe[2]	Australia & New Zealand	Africa[3]	Asia	Latin America[4]
Reviewer Region							
North America	0.51	0.45	0.52	0.45	0.58	0.46	0.43
United Kingdom	0.46	0.52	0.52	0.52	0.48	0.49	0.70
Other Europe	0.53	0.52	0.59	0.53	0.56	0.54	0.48
Australia & New Zealand	0.53	0.52	0.53	0.64	0.57	0.58	0.39
Africa (primarily South Africa)	0.54	0.37	0.64	0.47	0.81	0.00	0.49
Asia	0.64	0.58	0.73	0.69	0.40	0.76	-
Latin America	0.62	0.59	0.54	0.43	0.63	0.61	0.62

[1] The United States and Canada; [2] Europe excluding the United Kingdom; [3] Entirely South Africa; [4] includes South America, Central America, Mexico and the Caribbean countries.