Biodiversity knowledge synthesis: an introduction to meta-analyses and systematic reviews
- Risks of bias -

4/10/23 - Montpellier

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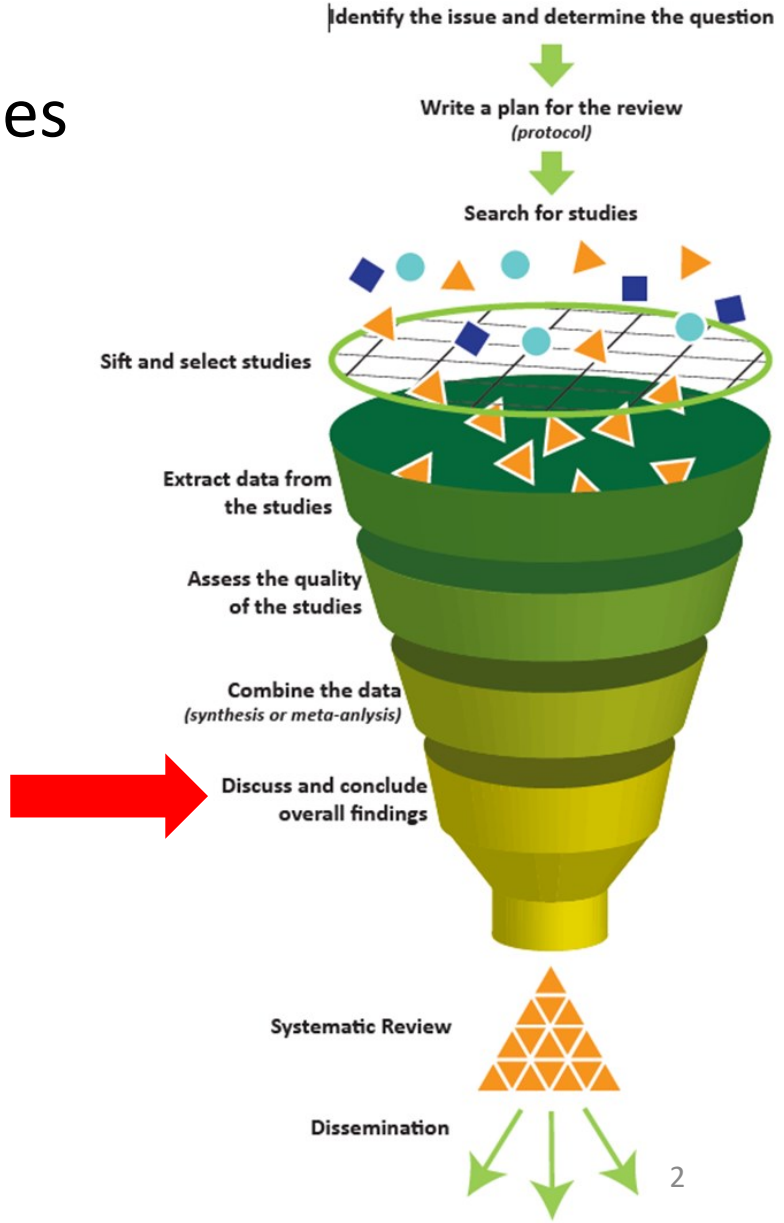
Risks of bias in meta-analyses

Meta-analysis = combine the results of primary studies to determine an overall effect
(+ analysis of heterogeneity)

→ assumes that the primary studies collected are a **representative sample** of all available studies



Jessica Kaufman, Cochrane Consumers & Communication Review Group, Centre for Health Communication and Participation, La Trobe University, 2011.

Risks of bias in meta-analyses

… but studies showing a statistically significant effect are more likely to be

- published → publication bias
- published rapidly → time-lag bias
- published in English → language bias
- published more than one time → multiple publication bias
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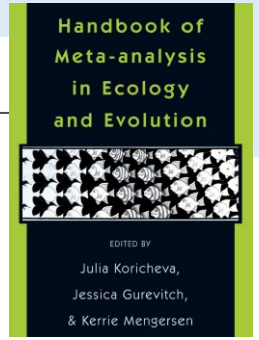
Publication bias: visual detection

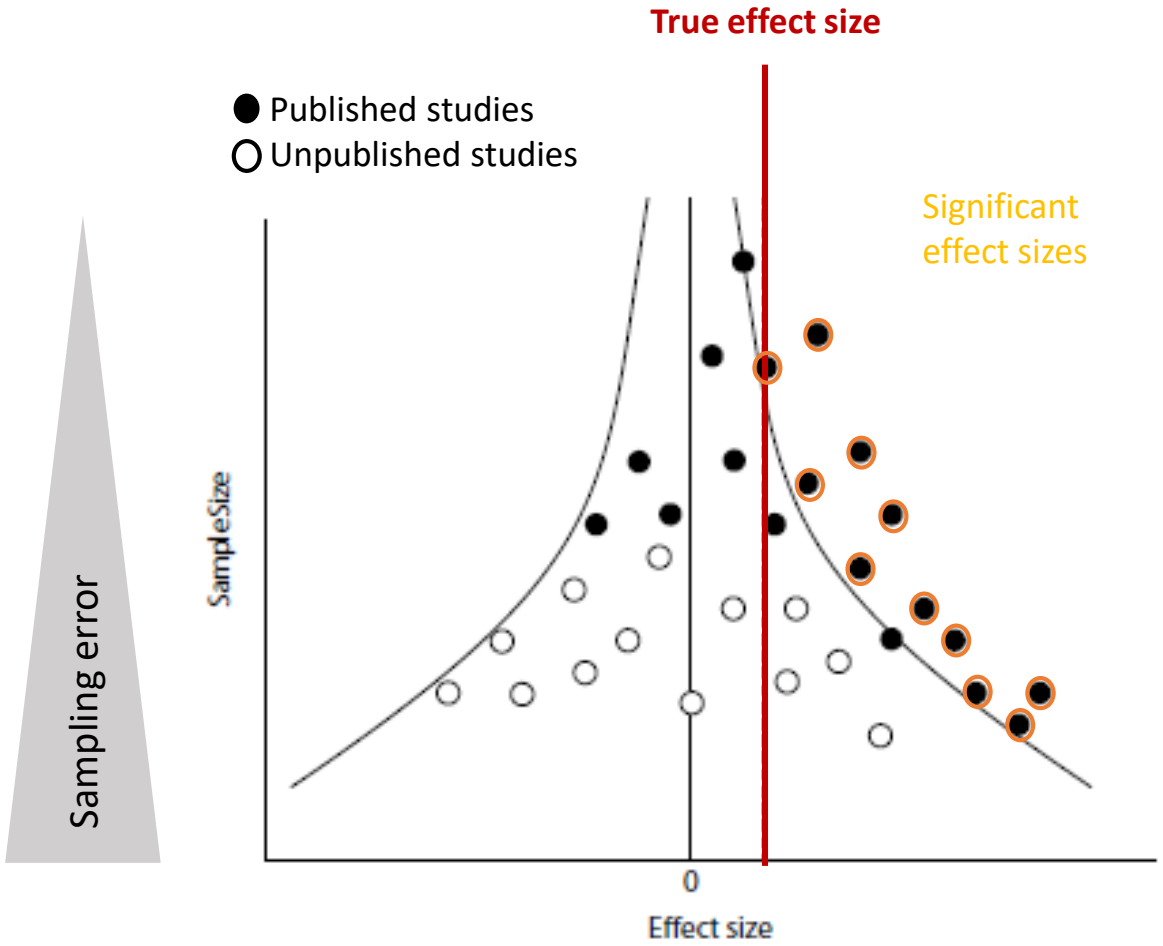
14

Publication and Related Biases

Michael D. Jennions, Christopher J. Lortie, Michael S. Rosenberg, and Hannah R. Rothstein



Funnel plots



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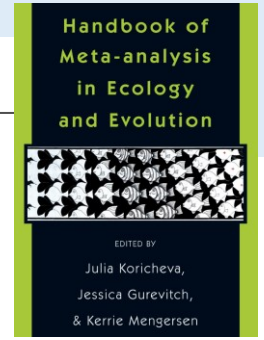

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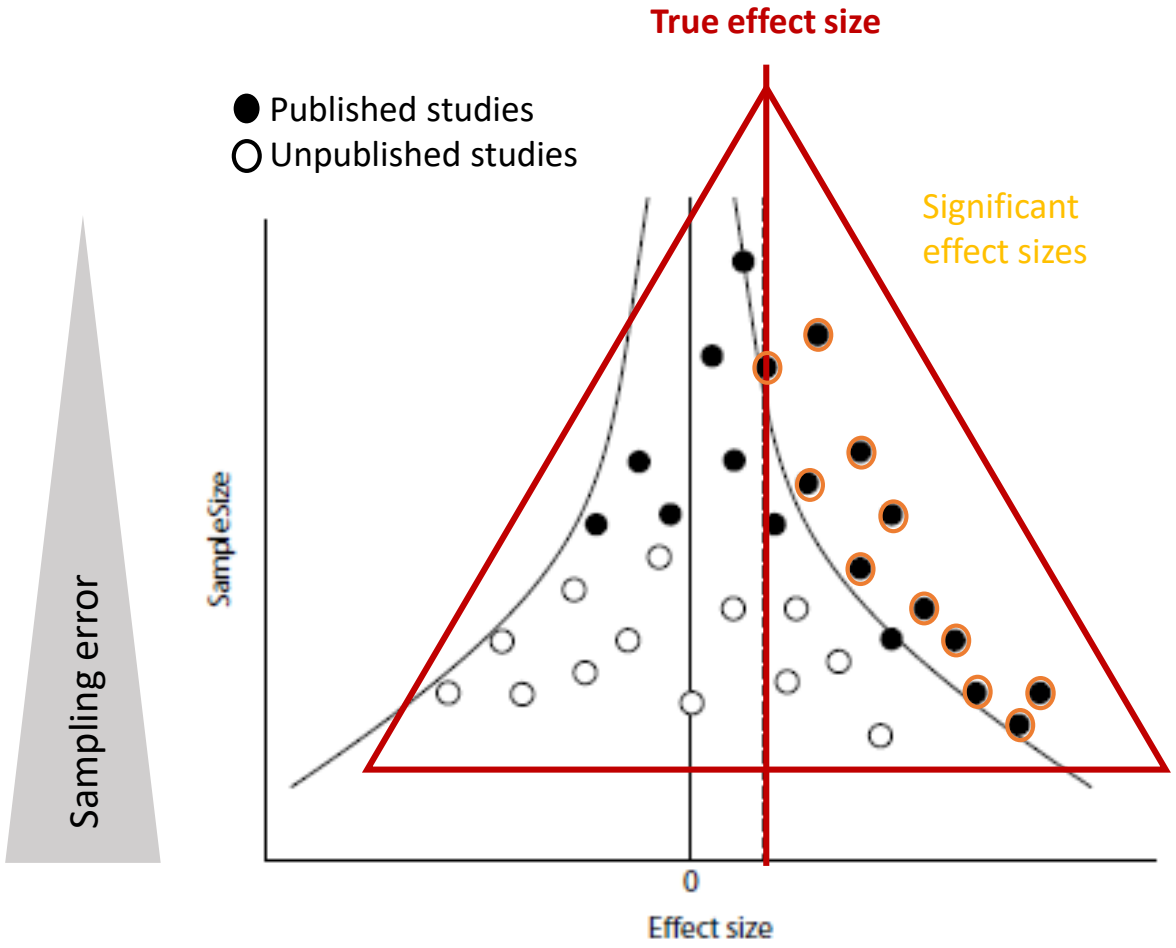

The distribution of all the studies around the true effect is symmetrical

Publication bias: visual detection

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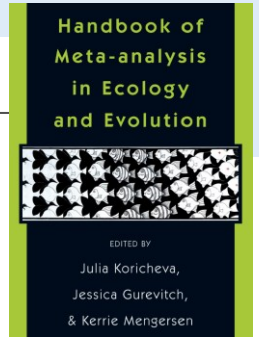

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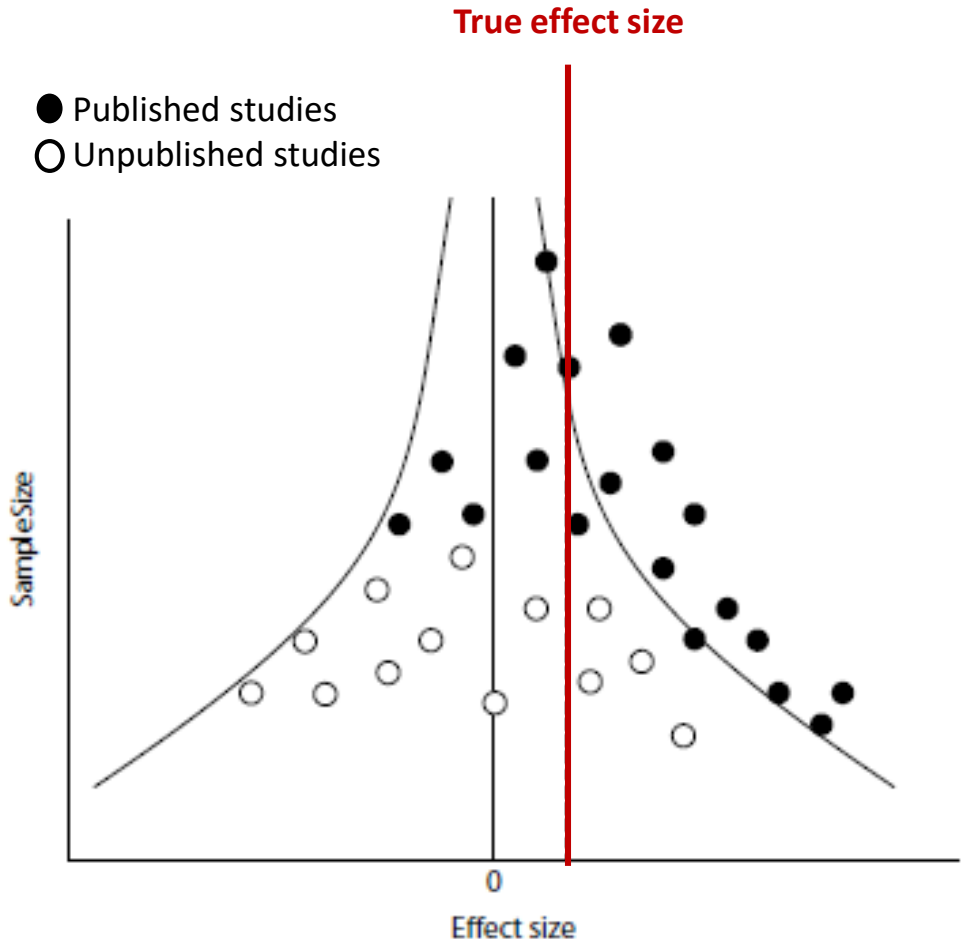

The distribution of all the studies around the true effect is symmetrical

Unpublished studies have **small sample sizes** and non-significant results

Publication bias: visual detection

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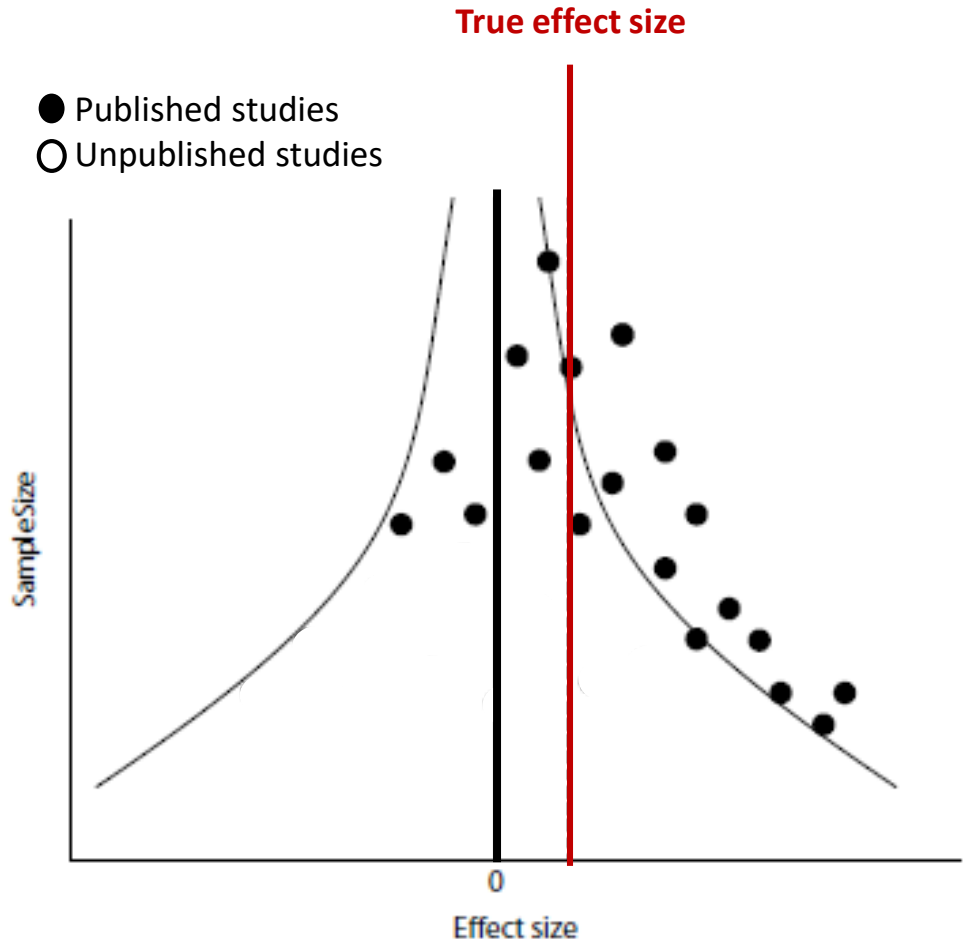

The distribution of all the studies around the true effect is symmetrical

Unpublished studies have **small sample sizes** and non-significant results

→ an **asymmetric distribution** of the effect sizes of published studies ("**small-study effect**")
→ a relationship between sample size and effect size
→ an overestimation of the true effect

Publication bias: visual detection

Received: 8 April 2021 | Accepted: 6 September 2021
DOI: 10.1111/2041-210X.13724
REVIEW ARTICLE
Methods in Ecology and Evolution

Methods for testing publication bias in ecological and evolutionary meta-analyses

Shinichi Nakagawa[1] | Malgorzata Lagisz[1] | Michael D. Jennions[2] | Julia Koricheva[3] | Daniel W. A. Noble[2] | Timothy H. Parker[4] | Alfredo Sánchez-Tójar[5] | Yefeng Yang[1] | Rose E. O'Dea[1]

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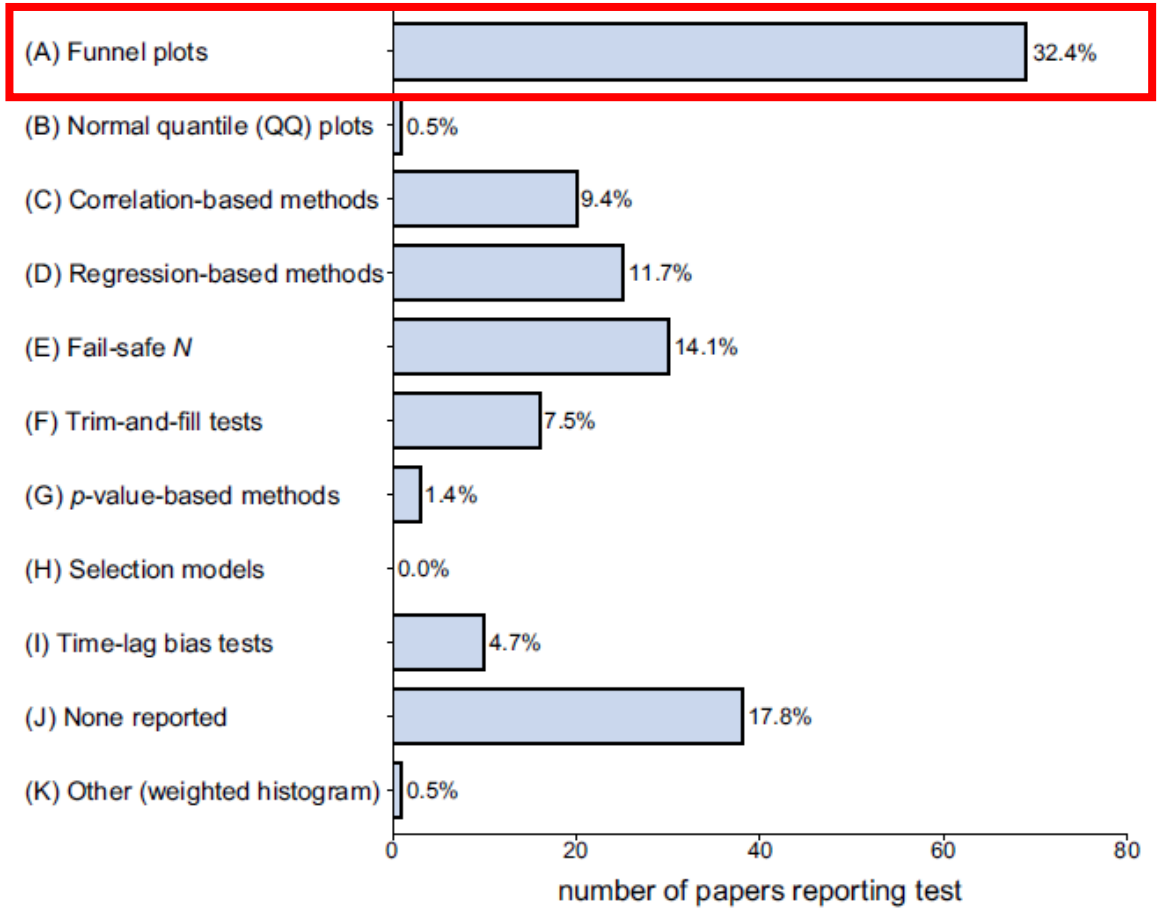

Effect size ~ N, SE, variance, precision (1/SE), inverse variance

Most popular method

! Warning: asymmetry may be due to effect sizes heterogeneity

Publication bias: detection tests

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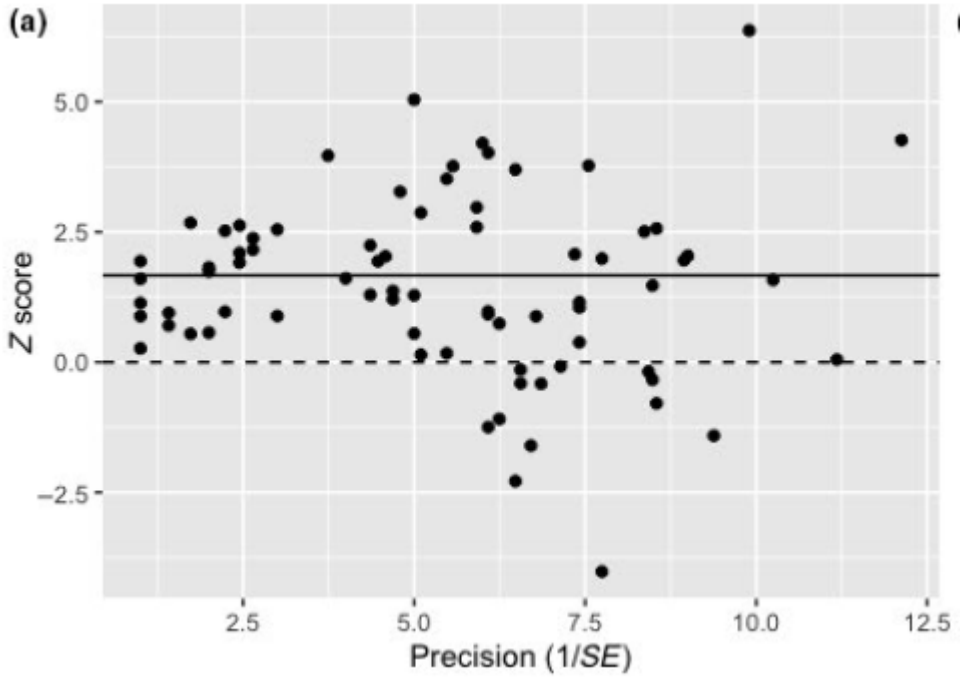
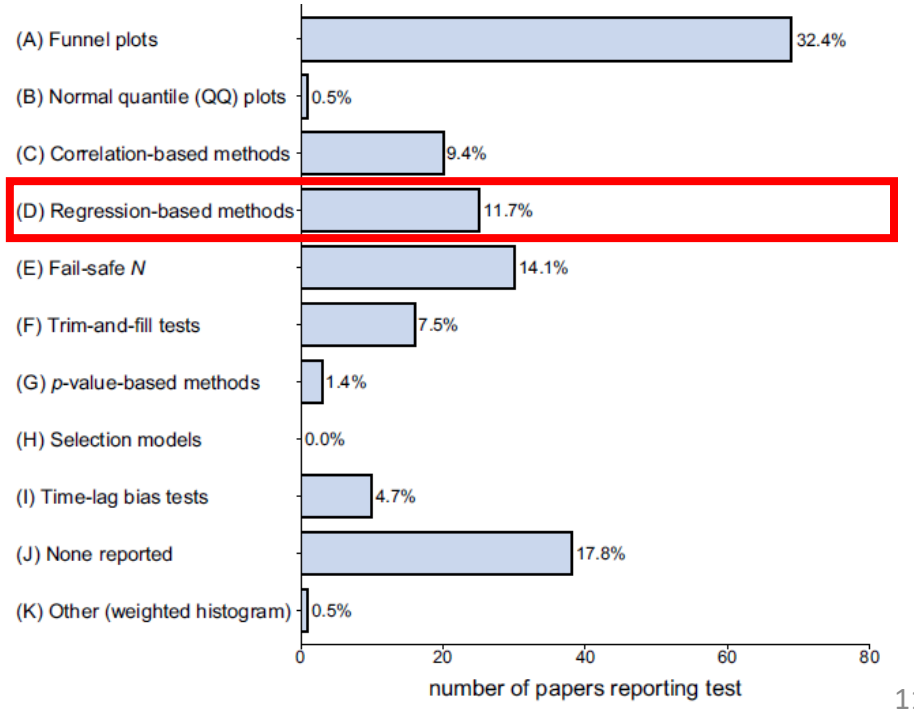
Testing funnel plot asymmetry

- **Egger's test** : linear regression of effect sizes/SE ~ 1/SE

If the intercept is stat. signif. different from 0 → asymmetry stat. signif.





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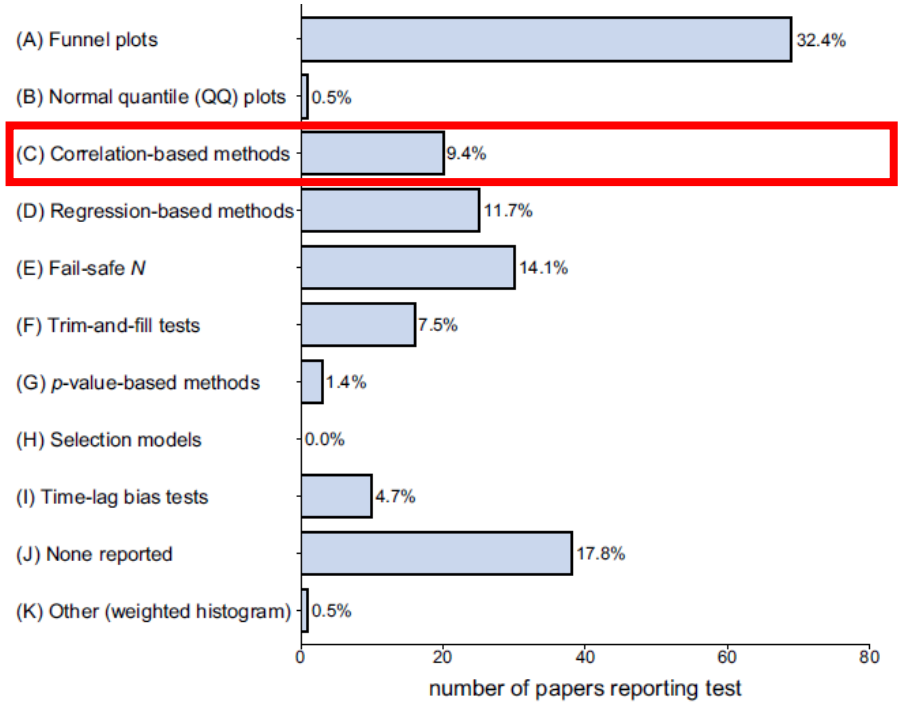
Testing funnel plot asymmetry

- **Correlation test** : non parametric test of the correlation between standardised effect size and variance (or another measure of uncertainty)

Egger's regression preferred



Publication bias: assessment of the impact

Fail-safe N

= number of unpublished stat. non-significant needed to make the overall effect not significant

If the fail-safe N is high (> $5*N_{studies}+10$) results are considered to be robust to publication bias

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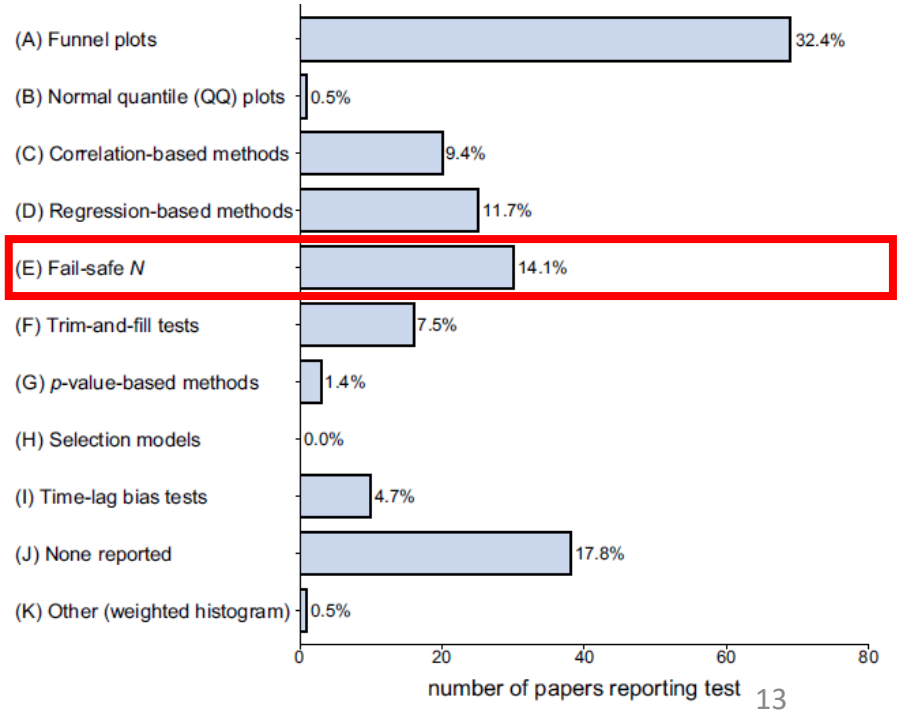
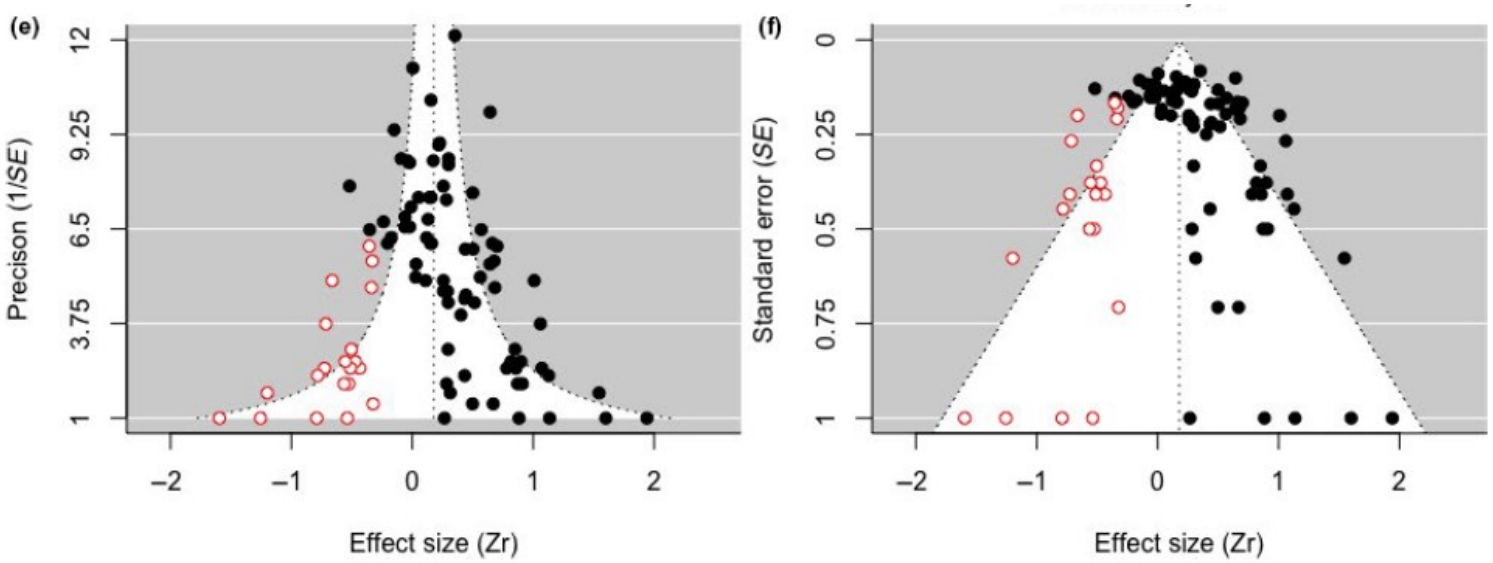


Publication bias: assessment of the impact

Trim-and-fill

Visualisation of potentially missing effect sizes and re-estimation of the overall effect



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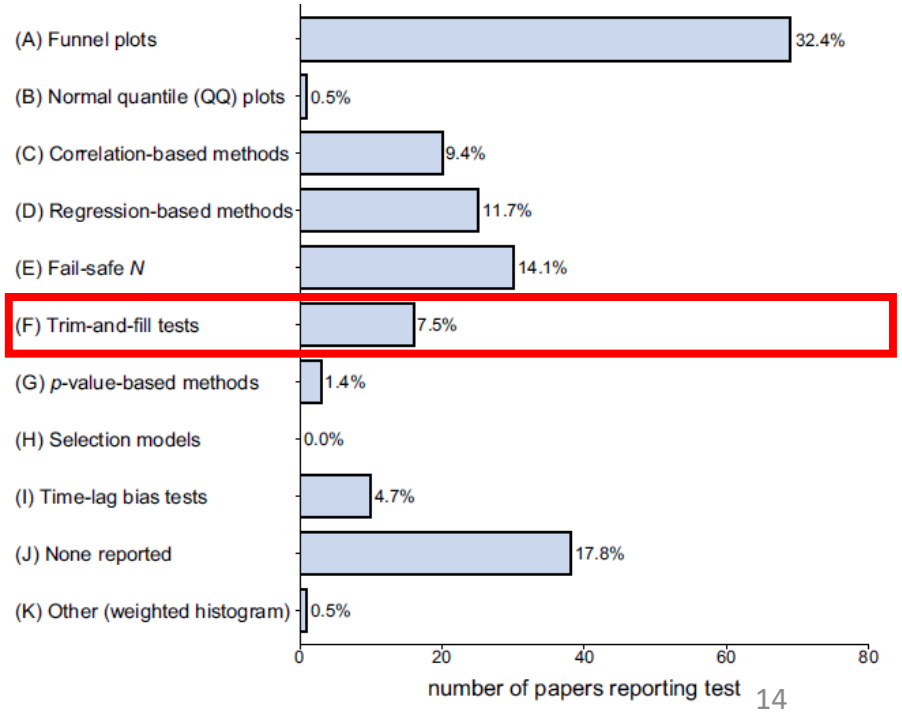

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Proposal of a **new method (multilevel meta-regression)** for detecting and correcting publication bias. The method takes into account the **heterogeneity** and **dependency** of effect sizes.

Publication bias: modelling

Nakagawa *et al. Environmental Evidence* (2023) 12:8
https://doi.org/10.1186/s13750-023-00301-6

Environmental Evidence

METHODOLOGY Open Access

Quantitative evidence synthesis: a practical guide on meta-analysis, meta-regression, and publication bias tests for environmental sciences

Shinichi Nakagawa[1,2*], Yefeng Yang[1*], Erin L. Macartney[1], Rebecca Spake[3] and Malgorzata Lagisz[1]

https://itchyshin.github.io/Meta-analysis_tutorial/#checking-for-publication-bias-and-robustness

- **Detecting small study effect**

The most well-known form of publication bias is the **small study effect**, where effect size values from a "small" studies, with low replication and therefore large uncertainty and low precision, show different, often larger, treatment effects than large studies. A straightforward way to detect small study effect is to add the uncertainty of effect size as a moderator, such that the relationship between effect size and its uncertainty can be quantified. We propose to formulate Egger's regression (which is a classic method to detect the symmetry of a funnel plot) in the framework multilevel model to detect the small-study effect for dependent effect sizes:

to detect

$$z_i = \beta_0 + \beta_1 \sqrt{\frac{1}{\tilde{n}_i}} + \mu_{j[i]} + e_i + m_i, (16)$$

to correct

$$z_i = \beta_0 + \beta_1 (\frac{1}{\tilde{n}_i}) + \mu_{j[i]} + e_i + m_i, (17)$$

β_0 = publication-bias-corrected overall effect

Sampling error $\sqrt{\nu_i}$ is a typical measure of effect size uncertainty z_i. However, for some types of effect size, for example, SMD, z_i has a intrinsic relationship with its ν_i (see **Table S2**). Therefore, ν_i is not a valid moderator for detecting a small-study effect. In Equation 16, we use an adapted sampling error based on effective sample size $\tilde{n}$ as the moderator. Let's calculate $\tilde{n} = \frac{n_{tC} n_{tT}}{n_{tC} + n_{tT}}$ for SMD in our example (see **Table S2** for formulas for other effect sizes):

```
ess.var_cal <- function(dat){1/dat$n_control + 1/dat$n_treatment} # write a hel
dat2_Midolo_2019$ess.var <- ess.var_cal(dat2_Midolo_2019) # calculate tilde N
dat2_Midolo_2019$ess.se <- sqrt(dat2_Midolo_2019$ess.var) # calculate adapted s
```

Then the Equation 16 can be fitted with:

```
mod_MLMR_lnRR_ess.se <- rma.mv(yi = lnRR,
                               V = VCV,
                               mods = ~ ess.se, # add adjusted based sampling er
                               random = list(~1 | Study_ID,
                                             ~1 | ES_ID),
                               method = "REML",
                               test = "t",
                               data = dat2_Midolo_2019
                               )
```

Accounting for heterogeneity when detecting publication bias

$$z_i = \beta_0 + \beta_1 \sqrt{\frac{1}{\tilde{n}_i}} + \sum \beta_h x_{h[i]} + \mu_{j[i]} + e_i + m_i$$

Risks of bias in meta-analyses

… but studies showing a statistically significant effect are more likely to be

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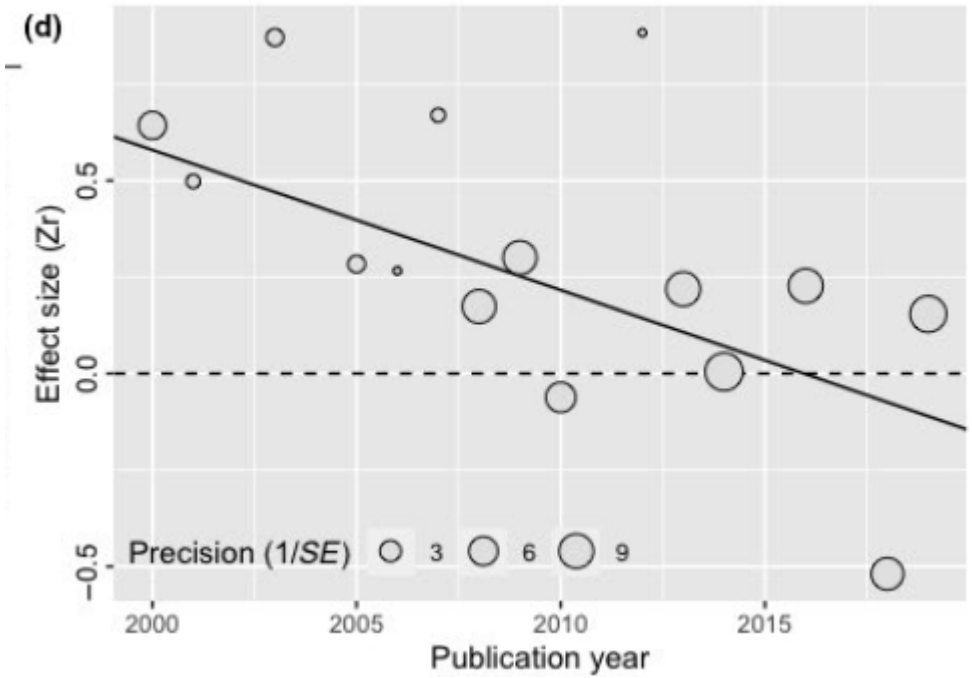
Time-lag bias

Correlation between *effect size* and publication year



Not recommended, does not consider precision

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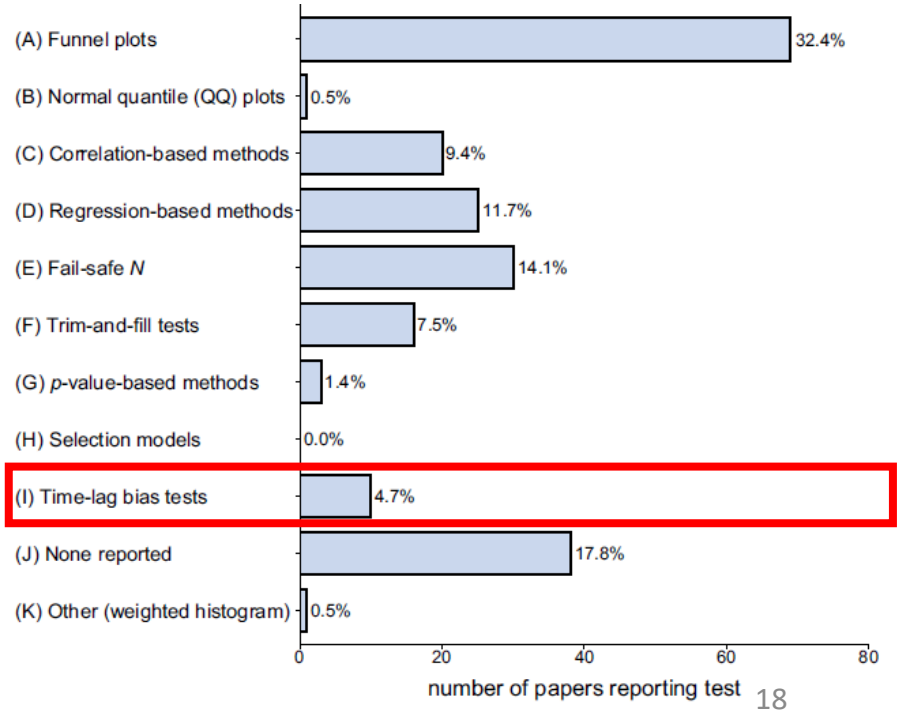
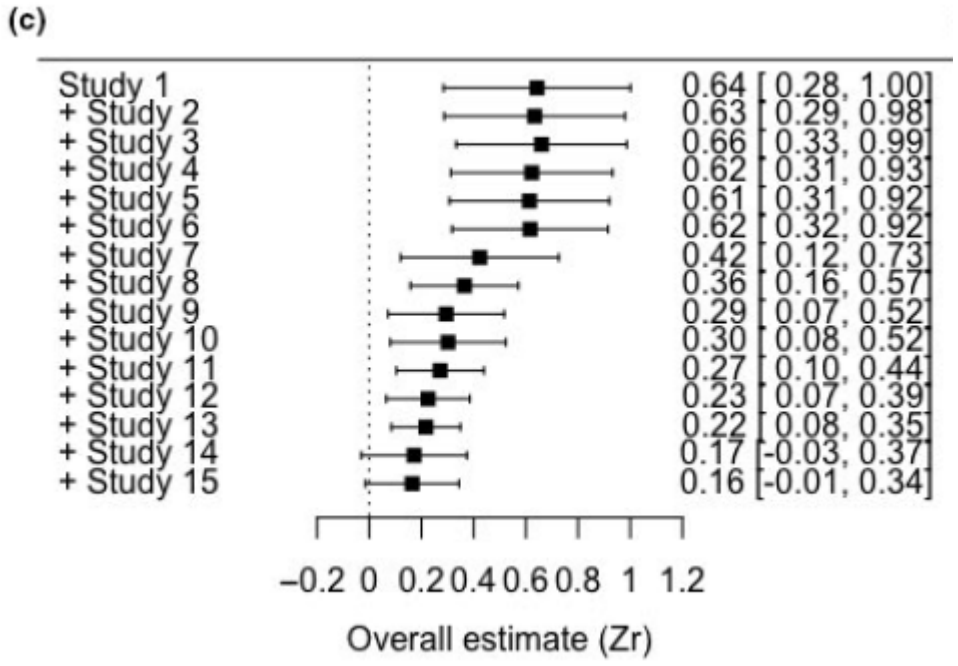


Time-lag bias

Cumulative meta-analysis

The larger the number of studies, the more we converge on the true effect



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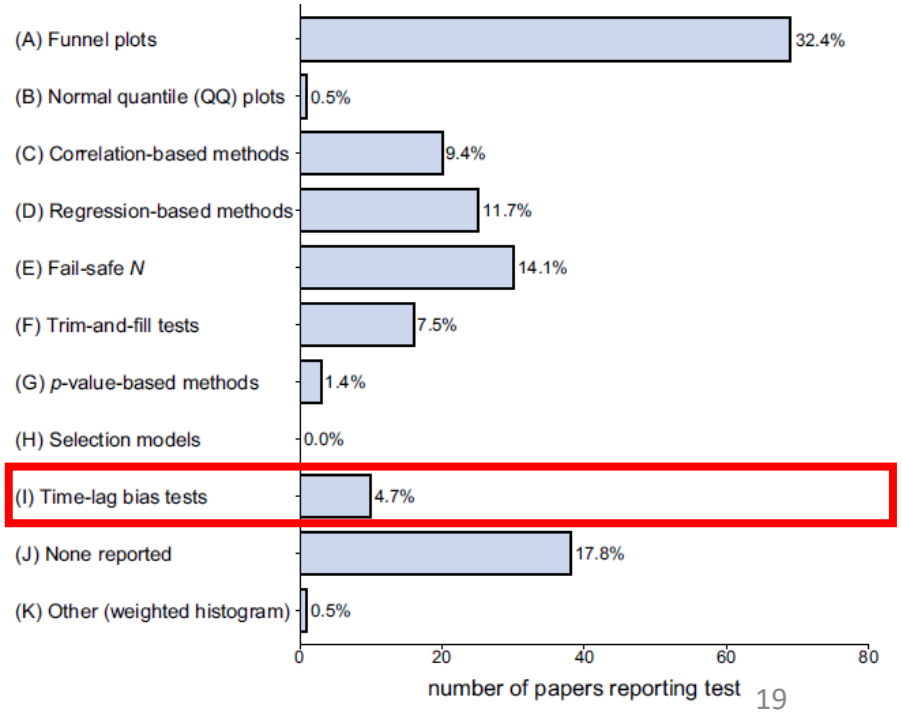

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- **Detecting decline effect**

The decline effect, also known as time-lag bias, is another prominent form of publication bias, where effect sizes tend to get closer to zero over time. Testing for a decline effect is important because the temporal changes in evidence of a given field poses a threat to environmental policy-making, management, and practices. Decline effects can be tested by a meta-regression with publication year (centered to ease interpretation: $c(year_{j[i]})$) as a moderator:

$$z_i = \beta_0 + \beta_1 c(year_{j[i]}) + \mu_{j[i]} + e_i + m_i, (18)$$

Accounting for heterogeneity when detecting publication bias

In our main text, We introduce Equation 19 to simultaneously detect two forms of publication bias while accounting for heterogeneity to increase power and reduce Type I error rate:

$$z_i = \beta_0 + \beta_1 \sqrt{\frac{1}{\tilde{n}_i}} + \beta_2 c(year_{j[i]}) + \sum \beta_h x_{h[i]} + \mu_{j[i]} + e_i + m_i, (19)$$

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Language bias

Received: 11 February 2020 | Revised: 20 April 2020 | Accepted: 23 April 2020
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Ecology and Evolution Open Access WILEY

Ignoring non-English-language studies may bias ecological meta-analyses

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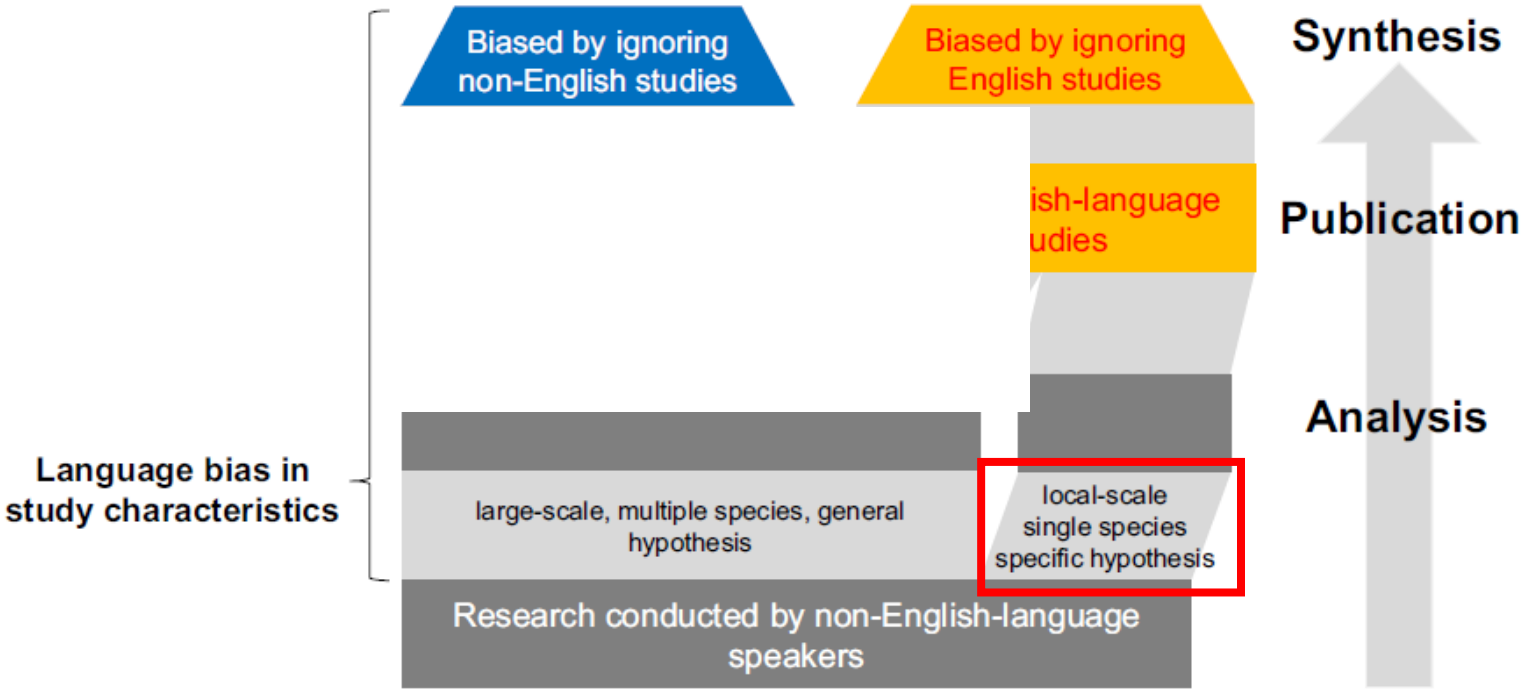

Studies on a local scale, focusing on one species or testing specific hypotheses are more likely to be published in a non-English language

→ Language bias linked to the characteristics of the study

Language bias

Studies showing a statistically significant effect are more likely to be published in journals with a higher impact factor, in English
→ Language bias linked to the statistical results of the study

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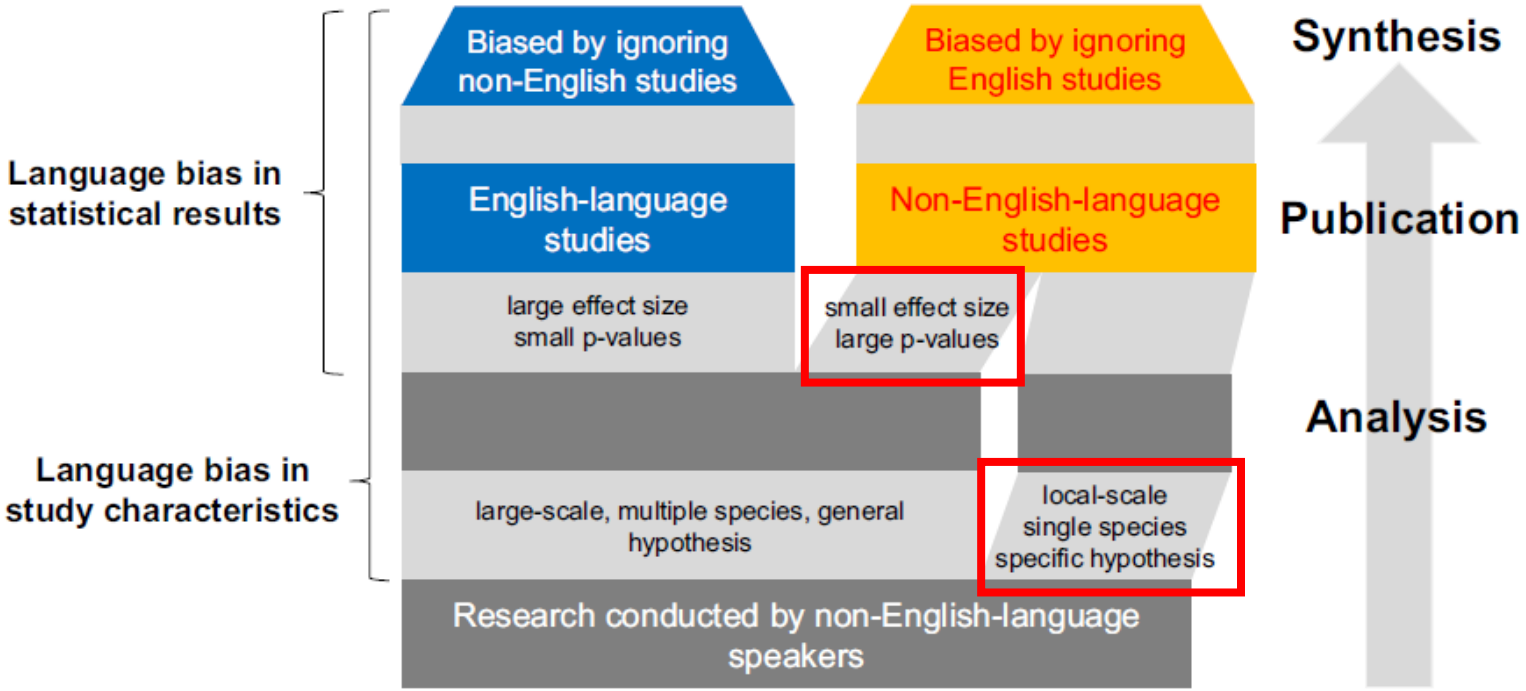

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Meta-analysis	Levene's test for homogeneity of variance		Two-sample Kolmogorov–Smirnov test for normality		Two-sample *t* test for effect-size differences between languages	
	F (*df*)	*p*	*D*	*p*	*t* (*df*)	*p*
Rice-field meta-analysis	0.13 (1, 56)	.72	0.44	.06	2.18 (56)	**.03**
Leaf life span meta-analysis	4.55 (1, 132)	**.03**	0.27	.08	−2.40 (38.42)	**.02**
Plant forestry meta-analysis	1.68 (1, 63)	.20	0.29	.12	−0.19 (63)	.85
Sapling forestry meta-analysis	6.07 (1, 39)	**.02**	0.36	.17	−2.03 (21.62)	.05

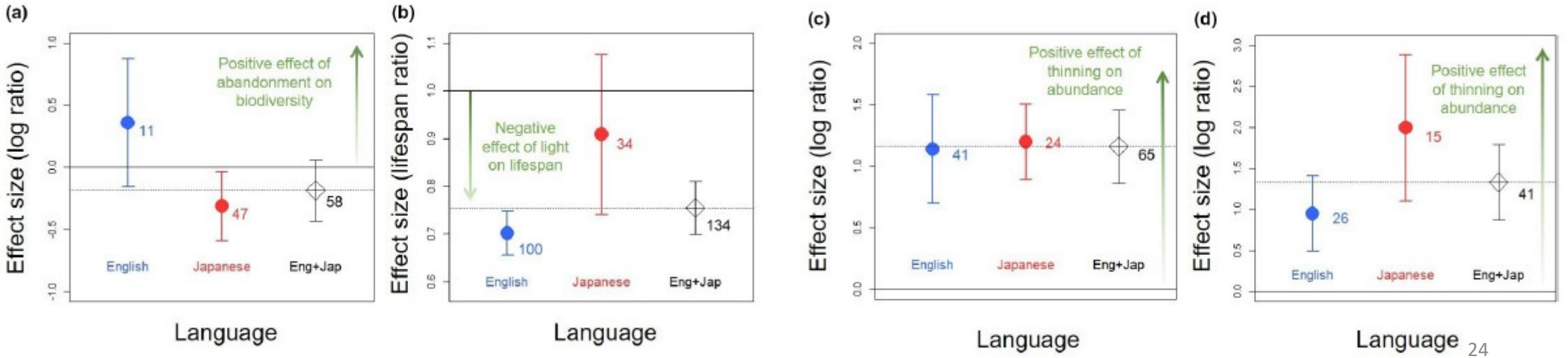
Note: Statistically significant results are in bold. Welch two-sample *t* test was used where the assumption of homogeneity of variance was not met.

Effects of rice-field abandonment on biodiversity

Effect of light on plants' leaf life span

Effect of thinning on groundlayer plant abundance

Effect of thinning on sapling and seedling abundance



Conclusion

- **Importance of literature search!**

→ search for grey literature
→ include literature published in non-English languages

- Publication bias tests should always be **interpreted with caution**, as there is no method for checking the real number of missing studies